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Review

Relevance and feasibility of the existing social LCA methods and case studies from a decision-making perspective

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ABSTRACT

This paper explores the existing social life cycle assessment (SLCA) literature (theoretical and case studies) from decision making perspective. In order to tackle this, a critical review of 90 published work, including journal papers, conference proceedings and book chapters was undertaken. The selected articles were analyzed with a focus on methodological framework, boundary scoping, data inventories and practices. The analysis highlighted the inadequacies in the existing frameworks in terms of flexibility, conflicts in choosing and defining Area of Protection (AoP). Lack of consideration of social conditions of stakeholders in no-work and no-use phase, lack of inclusion of positive impacts, less attention to suppliers and consumers and choice of subjective indicators are highlighted as some weak portions within the boundary scoping. Less coverage of contextual and indirect indicators, and absence of documentation of a link between data collected (subjective indicators) and product activities are highlighted as a limitation within inventories, and finally within practices, lack of benchmarks is highlighted. This analysis highlighted an important differentiating factor between the actual definition of sustainability (maintenance of stocks for future generation) and the most common interpretation in literature as a summation of the three (social, environmental and economic) indices.

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1. Introduction

Rising interests and pressing need to assess the social impacts (positive and negative) of a product along its entire life cycle has made Social Life Cycle Assessment (SLCA) the major focus of scientific community and organizations. Since the publication of UNEP/SETAC guidelines (Benoît-Norris et al., 2011), numerous Social life cycle impact assessment (SLCIA) frameworks and characterization models have been developed to assess the social impacts of products globally across various industries. SLCA has definitely emerged as a very powerful and necessary tool in the field of sustainability and aids in overall decision making (Fan et al., 2015). Jørgenson et al. (2012) distinguished three different decision outcomes that could be derived by using existing SLCIA methods for improving the social conditions of workers: consequential SLCA, educative SLCA and lead firm SLCA. The distinction between these decision outcomes is explained in details by the author in their work. Jørgenson et al. (2012) hypothesized the three possible decision outcomes of using SLCA and used empirical findings from relevant research fields to validate this hypothesis. It was more a theoretical study trying to address how SLCA can be better developed to achieve its overall goal, hence existing SLCA studies were not analyzed in their work. Instead the 3 decision outcomes hypothesized were outlined reflecting upon their distinct features and overlaps. Also the scope of the study was limited to stakeholder workers. Decision outcomes from SLCA might improve the working conditions of one stakeholder group like workers, but might affect or translate negatively to other stakeholders like company (increased production costs) and consumers (increased price). Hence to avoid this tradeoff, decision making related to the improved social conditions of the workers was the only focus in Jorgensen's work.

While different researchers employed different SLCA techniques to derive a result (decision outcome) for their study, hardly any review has been undertaken to categorize these outcomes and analyze the possible factors that weakened these results when SLCA was used. Most of the reviews focused on reviewing the different impact assessment methodologies in SLCA from different perspectives. Some focused on describing overall limitations in SLCA methodologies (Jørgenson et al., 2007; Ramirez et al., 2011); some classified impact assessment methods into types (Parent et al., 2010; Chhipi-Shrestha et al., 2014; Wu et al., 2014); few focused on overview of social impacts on specific products/processes like ICT (Arushanyan et al., 2014; Wilhelm et al., 2015; Ekener Peterson and Finnveden. 2013) and biodiesel production (Macombe et al., 2013); scientific justification for the usage of three indicators: working hours, child labor and property rights only was carried out by Arvidsson et al., (2014); need for more scientifically sound SLCA methods in place of judgmental assessments was emphasized by Grubert et al., (2016); only characterization and weighing approaches were dealt with by Garrido et al., (2016); systematic literature review categorizing articles by year, journal, system boundaries was carried out by Petti et al. (2016); fragmented SLCA methods was once again confirmed but using a different tool like automatic text analysis (Arcese et al., 2016). Outside methodologies, a couple of reviews focused on Social Hotspot Database (SHDB) development and its features (Benoit-Norris et al., 2012a, b; Norris et al., 2014). This said, the present article takes on a different approach. This work differs from the previous reviews in the (1) classification framework used for categorizing articles (based on their decision outcomes/results of the study) and (2) the basis of this review (focusing on factors that weakened the decisions made in the reviewed studies from the researchers' perspective itself). The challenges and limitations faced by the researchers while using SLCA for deriving decisions were identified, analyzed and classified into four macro categories in this work, which has not been done so explicitly in previous reviews. Also, areas within IA like Area of Protection (AoP), boundary setting, indicator relevance are also analyzed in detail which were not dealt with in much detail in earlier reviews. The other important differentiating factor is the analysis of the social LCA within sustainability and its current interpretation and usage within studies. To our knowledge, this has not been done in much detail in earlier reviews. The entire analysis has been carried out with the focus on decision outcome i.e. how these factors have influenced the results of the reviewed studies and how better decisions could be made using SLCA. The synthesis of the literature is presented from the individual researchers' (authors of the reviewed articles) perspective in relation to decision outcomes. By doing so, it aims to highlight that the key elements that make the decision outcomes weak (reduce the possibility of deriving more accurate results) are not so much the scoring techniques used and the aggregation methods followed but rather the AoP defined, data collection techniques used, choice of indicators employed, interpretation of sustainability, weak link between theoretical frameworks developed and practices and finally boundary setting that are used in SLCA. Moreover, for SLCA to work and stop being termed as being in an infancy stage, should deliver decision support when used and improve social conditions of the stakeholders throughout the product's life cycle based on the results derived (decision outcomes). Identifying problems/limitations that hinder derivation of these decision outcome when SLCA is used is the most pressing research topic to be addressed (Jørgensen, 2013). This paper therefore takes on the task of exploring what kinds of decisions are made using SLCA and whether there are any inherent drawbacks that weaken these outcomes derived. This inquiry leads to some simple questions that have to be answered: When researchers use SLCA (1) what do they intend to protect? (2) Are the practices in line with theoretical frameworks developed? (3) What is the existing interpretation of sustainability within the LCSA studies? (4) Any major players being excluded in the boundary setting? (5) What are the types of data collection techniques used and why is it difficult to collect data? (6) Is SHDB universally applicable? (7) Does choice of indicators affect boundary setting and impact assessment (IA)? Ultimately, this kind of inquiry has led us to identify some inadequacies in the existing SLCA methods and practices that

hinder its usage as a decision-making support tool, while acknowledging and taking into consideration the rapid growth development of numerous SLCA methods and increasing number of case studies in recent years.

Before presenting the research methodology and samples that guided this literature review, an overview of the current usage of SLCA and the different types of decision outcomes derived are presented in Section 2.

2. Decision outcomes from SLCA studies

The first mention of decision making in SLCA was encountered in Jørgenson et al.'s (2009) work, who suggested that decision making should be the primary outcome of any SLCA study and will definitely create changes in the product's life cycle. According to Jørgenson et al. (2012), three different decision outcomes that can possibly be obtained from using the existing SLCIA methods are: (1) "Consequential SLCA" to choose between decision alternatives, whose results create influences the production level of the companies; (2) "Educative SLCA" in which a good SLCA score that can be communicated to the market for competitive advantage, whose results influence the production level and the conduct of the company; (3) "Lead-firm SLCA" to identify primary hot-spots, whose results create effects on the conduct of the companies.

Building upon these definitions, the existing SLCA studies were classified into 4 categories based on their results (decision outcomes): (1) simply assess social impacts (2) SLCA results used for comparative purposes (3) hot spot identification and (4) SLCA used within life cycle sustainability assessment (LCSA) to derive an overall sustainability score. The first three categories match with Jorgenson et al.'s hypothesis, while the fourth one is related to sustainability assessments. Within the fourth category also comparative analysis is carried out, but SLCA is not the only dimension analyzed like in other 3 categories, hence studies that carried out ELCA or LCC alongside SLCA fall into this fourth category.

Those articles describing general guidelines are not included in the classification, however included in this review and some important limitations related to decision making from the authors perspective are presented (Table 1). Within the 53 case studies that were identified in this review, 14 studies used SLCA to only assess social impacts in different life cycle stages of the product, in 13 studies the SLCA results were used to compare product/system alternatives and 3 studies conducted a comparison between SLCA and ELCA for the same functional unit (Chang et al., 2015; Ciroth and Franze, 2011; Rugani et al., 2015), in 5 studies hot spot identification was carried out and in 21 studies SLCA was used within LCSA to derive an overall sustainability score. Within LCSA, 9 case studies carried out a comparative LCSA.

3. Methodology

3.1. Research sample

To tackle this work, an extensive review was undertaken covering a total of 90 published work. There was no restriction in terms of time frame. A comprehensive review primarily based on journal articles and to some extent on conference proceedings, reports and book chapters was carried out. The relevant published literature was searched using appropriate keywords ("Social Life Cycle Assessment", "SLCA", "Social LCA", "Societal LCA", and "Life cycle sustainability assessment") in search engines (Google Scholar and One Search of Hong Kong Poly U) and online database (SCOPUS).

The resulting bibliography of over thousands of references were then screened by reviewing the titles and the abstracts of the articles. Further to this first level of screening, every selected document was carefully examined for their relevance before inclusion into this study. By relevance, it means the articles should either present a developed SLCA method (Social LCA methods-theoretical-22 articles) or employ a developed one (case studies-53 articles) or an existing review in this area (15 articles). Those articles were then analyzed based on their decision outcomes and the factors affecting the same are recorded in Table 1. The details of the existing reviews are presented in Section 1. An excel file was used to record the limitations of the reviewed studies. As we filled for each of the selected article, the limitations majorly divided into more precise categories like methods, data, boundaries setting and sustainability interpretation. Some important arguments placed by authors in relation to decision outcomes were also noted down. This method allowed identifying the important aspects like data collection techniques, system boundaries set, methods used for impact assessment (IA), AoP defined, sustainability interpretation, and practices followed that needs to be addressed to make SLCA deliver decision support when used by researchers/practitioners both individually for product assessment and within sustainability. The classification framework used to categorize the reviewed studies is explained in the previous section. The synthesis of the classified literature is described below.

3.2. Comparative analysis of decision outcomes from the studies

Table 1 shows the synthesis of literature under different decision outcomes. There might be an overlap within few studies, for instance Hosseinijou et al. (2014) carried out a hot spot analysis to compare two alternatives, however the study is classified under comparative purpose based on the goal of the study stated by the author. In the literature authors' implicit or explicit presentation of the decision/results derived from the study vary, some vaguely explain in the interpretation section, while in some it may not be so clearly presented. Hence, for the sake of explicitly identifying the important aspects that play a key role in making SLCA a decision support tool, we propose to first classify the articles, analyze the factors that weaken the decision outcomes of the studies based on the recommendations/limits according to the published articles, identify few categories within which these factors fall and then describe them individually.

4. Findings

Table 1 shows the various limits/future needs for better decision outcomes using SLCA according to the SLCA studies reviewed. It shall be noted that all the limitations/factors presented above that affect the decision outcome of the studies while using SLCA fall into four macro categories namely (1) Methodology framework; (2) Boundary setting; (3) Data inventory and (4) Practices. The description and basis of the critical review of SLCA literature is depicted in Fig. 1. The micro-categories identified are linked to the four macro-categories. It shall be noted that there is a weak broken link between the existing methodology framework and practices in the literature. In literature, authors' implicit or explicit definition/explanation of the above four key factors vary. For the sake of making explicit the key factors that affect the use of SLCA as a decision support tool, we propose to describe them individually.

Methodology framework refers to the Impact Assessment (IA) methods developed by authors. Generally, data collection, goal and scope are parts of methodological phases, but in this work, it refers to only the impact assessment frameworks developed. The IA frameworks belong to Type 1 (Performance reference point (PRP) methods) or Type 2 (Impact pathways methods), some are company oriented (e.g. organizational, management); some are

Table 1
Synthesis of Literature based on four decision outcomes.

Ref sources	Limits/Recommendations for better decision outcome/results according to articles under review
Decision Outcome: Assessing social impacts	
Hunkeler (2006)	• Define a method that is LCI derived, geographically specific, based on mid points and use employment as an intermediate variable
Norris (2006)	• Develop a web-based reporting system making it possible to report the aggregated results of data over the supply chains of various life cycles • Implement site and company specific publishing of LCI
Ramirez (2012), Ramirez et al. (2014, 2016)	• Relate results along the life cycle, not only to the organization • Define methods that reflect social behavior of small organizations (SMEs) and cover positive actions
Aparcana and Salhofer (2013a and b)	• Propose indirect indicators based on preventive social policies • Propose semi-quantitative indicators related to perception of satisfaction, quality of life that cannot be precisely predicted
Arcese et al. (2013)	• Relate social indicators to the functional unit of the study • Develop quantitative indictors for tourism sector
Feschet et al. (2013)	• Define pathways to stabilize the relationship between economic growth of a country due to a product/sector and health status of its population
Manik et al. (2013)	• Determine system boundaries to be able to cover downstream processes including consumer stakeholder and the voice of importers as value chain actors
Smith and Barling (2014)	• Develop a method to implement SLCA in SMEs • Propose more indicators related to SMEs and their supply chains
Bouzid and Padilla (2014)	• Extend application of SLCA to agricultural activities rather than limiting to industries in the supply chain • Establish a link between working time and product value in IA
Nemarumane and Mbohwa (2015)	• Develop a generically applicable social impact assessment method
Umair et al. (2015)	• Device new business models for informal e waste sector under CSR scheme for better data availability leading to inclusion of all important sub categories in IA
Dong and S (2015)	• Develop a method to reduce inconsistencies due to normalization step in IA, combine quantitative and semi-quantitative indicators • Propose indicators related to few sub-categories to enable inclusion in IA • Device a method/way to reduce uncertainties owing to the usage of survey results in SLCA and check the reliability of the scales used in surveys.
Decision Outcome: Comparative analysis	
Dreyer et al. (2005, 2010a,b)	• Define a method to explicitly weigh direct and indirect indicators before possible aggregation and interpretation
Brent and Labuschagne (2006)	• Develop data quality standards to improve transparency of indicators • Propose indicators that address social issues influenced by cultural perception at national level and further combine at global level
Franze and Ciroth (2011)	• Integrate SLCA into routine decision support, including products with complex life cycle
Henrikke et al. (2013)	• Propose indicators that can be unambiguously interpreted in all social contexts and measure impacts as well as benefits • Develop more empirically based methods in place of common sense based frameworks, that considers stake holder health as the most important value to be protected
Lagarde and Macombe (2013)	• Define system boundaries for ELCA and SLCA in a coherent to enable comparison of results in a coherent way • Develop IA methods that can assess social impacts like cultural, political and institutional effects and help distinguish organizations that are more or less sustainable and those which are not at all • Define a pathway between job opportunities generated by the organization/product and the effect of change in the health of the population and workers
Lehmann et al. (2013)	• Propose indicators for comparative technology analysis that are technology specific and independent of company conduct • Improve sector specific data availability for developing countries (Indonesia in this case study) and involved supply chains in SHDB • Implement SLCA in more case studies for improved usability and applicability
Anne et al. (2014)	• Integrate research tools (AHP and MCD) in SLCA • Device a method for wider participation of affected stake holders to weigh the sub categories before choosing those for IA • Develop a method to deal with double counting of impacts within LCSA (can be differentiated by stakeholder participation)
Hosseinijou et al. (2014)	• Define better characterization models (currently only scoring systems) especially for comparing products as it needs a clear basis • Relate the impacts to functional unit, this will not limit the results to one time use but can be used as inference for other cases • Device a method to collect stake holder opinion at inventory level
Weldegiorgis and Franks (2014)	• Define a method that is geographically specific, special approach to combine qualitative and quantitative indicators
Wang et al. (2016a,b)	• Group social data of different countries from government statistics as PRPs to enable extended application of quantitative indicators • Determine weighing factors using wider participation of experts for better and reliable CFPR (consistent fuzzy preference relation) outcome.
Decision Outcome: Hotspot Identification	
Ekener et al. (2013a & b)	• Propose relevant indicators for subcategories with improved impact pathways • Device a special approach for improved assessment of use phase of computers
Ekener-Petersen et al. (2014)	• Device a method to aggregate results without treating all risks as equal and counting them, as this will lead to unbalanced result (Multicriteria decision making methods can be possible method) • Complement SHDB with site-specific data from case studies and literature • Conduct in-depth SLCA identifying severe risk in the supply chain and addressing social inequalities and variabilities rather than a screening SLCA identifying only risks
Jean et al. (2015)	• Implement pathways to establish a link between company behavior and social impacts (negative and positive) • Device methods to able to link ELCA and SLCA when used simultaneously on a product • Derive a clarity on causal relationship with the product at the core, whether company's behavior or the product itself • Develop a tool for quantitative data, mathematically modelled facilitating conceptual integration of ELCA and SLCA and not a mere procedural integration
Zamani et al. (2016)	• Develop a universally accepted set of product specific indicators by involving affected stake holders • Include cut-off criteria to include only sectors that directly affect the production system • Increase coverage of indicators in SHDB
Decision Outcome: SLCA with LCSA (Life Cycle Sustainability Assessments)	
Moriizumi et al. (2010)	• Present results in such a way it clearly describes its usage in decision making • Propose indicators to consider improved livelihood of people in de eloping countries due to product functioning
Ciroth and Franze (2011)	

(*continued on next page*)

Table 1 (*continued*)

Ref sources	Limits/Recommendations for better decision outcome/results according to articles under review
	• Device a method to reduce subjectivity while using qualitative data, special approach to address use phase of computers and equal weighing of subcategories
Traverso et al. (2012)	• Develop a method to weigh sets in life cycle sustainability dashboard (LCSD) • Implement an understandable yet comprehensive representation of results for non-LCA expert decision maker • Implement SLCA in more case studies to calibrate indicators and weights
Stamford and Azapagic (2012, 2014)	• Define a method to include the priorities and preferences of stake holders involved and weigh the impact of ELCA and SLCA individually before summation or comparison
Menikpura et al. (2012)	• Propose composite indicators that provide better decisions at policy level (e.g. DALY and potential employment opportunities)
Foolmaun and Ramjeawon (2012a,b)	• Develop a flexible method covering both qualitative and quantitative aspects and aggregated following a weighing step that relies on expert judgement and derived based on a priority scale (e.g. Analytical hierarchy process within MCDA)
Albrecht et al. (2013)	• Device a method based on quantitative science based information and built in social and emotional rules (customers)
Hu et al. (2013)	• Define sub-questions at goal and scope level for all three dimensions; • Develop technological models at micro level, scale it up with realistic scenarios from MFA studies at meso level and policy/economic studies at macro level
Luthe et al. (2013)	• Enable sustainable product design at planning stage itself with results derived; • Implement transparent communication of results to consumers and the market on how individual consumption impacts product system (labelling is a solution)
Vinyes et al. (2012)	• Relate results to the functional unit, device a method to weigh the individual dimensions of sustainability before summation • Define a method to reduce the subjectivity while using qualitative indicators and improve the weighing process in IA
Martínez-Blanco et al. (2014)	• Use working hours as an activity variable for aggregating social impacts along the life cycle • Clarity in the causal relationship between social indicators and the social targets they achieve • Implement strategies to strike a balance between site specific data and life cycle perspective, avoid considering national/sectoral data as a proxy for company data (lead to biased results) • Increased application and discussion of existing methods to improve them
Rugani et al. (2015)	• Propose contextual social indicators and high quality data sets
Basurko and Mesbahi (2014)	• Develop a method to conceptually integrate 3 dimensions of sustainability • Enable the results to aid decision makers to decide which tech/innovation is better and optimize operations
Musaazi et al. (2015) & Chang et al. (2015)	• Develop a method for conceptual integration of ELCA and SLCA after calculating weights of the individual sustainability dimension
Ren et al. (2015)	• Define a method that includes conflict criteria and attributes and derives an optimal solution without seeking compromise (e.g.: AHP for weighing and VIKOR within MCDA for ranking the alternatives)
Yu and Halog (2015)	• Design an approach to integrate affected stakeholders' opinion in the assessment
Souza et al. (2015)	• Define a structured pathway pathway/link between inventory, midpoints and endpoints (hierarchical level of issues) based on stakeholder perspectives • Use the developed method to compare similar decision situations but in different cultural context • Include stakeholder consultation for selection of impact categories in a LCSA
Agyekum et al. (2017)	• Develop scientific methods to aggregate results at sub-category level overcoming the complex nature of interdependencies existing within the social system • Increase data availability from SMEs in developing countries
Theoretical studies	
Grieβhammer et al. (2006)	• Implement SLCA in more case studies • Develop and establish well-defined social indicators • Compose a code of practice for SLCA
Weidema (2005)	• Develop a method to derive a single social score for measuring and protecting human well-being (e.g. QALY)
Hauschild et al. (2008)	• Integrate SLCA as a part of LCSA alongside ELCA and LCC
Hutchins and Sutherland (2008)	• Develop strategies for social sustainability and indicators for CSR
Kloepffer (2008)	• Restrict the numerous indicators to a manageable number • Relate social indicators to the functional unit
Jørgenson et al. (2009)	• Device a method to solve boundary setting issue in comparative assertions; special approach for use stage assessments and weighing social issues
Benoît et al. (2010)	• Foster application of UNEP guidelines in more case studies
Finkbeiner et al. (2010)	• Develop consistent and robust indicators for social and economic dimension within LCSA • Demonstrate understandable yet comprehensive presentation of results even for non-expert stakeholders (e.g. LSCD, LCST)
Jørgenson et al. (2010)	• Conduct valid assessments of the consequences of a decision relating to products • Identify social impacts due to the non-implemented product life cycle decisions (e.g. no-work phase, no-use phase)
Jørgenson et al. (2010)	• Develop valid impact pathways linking subjective indicators and the AoP
Norris et al. (2012)	• Implement SLCA in more case studies based on UNEP guidelines
Feshchet et al. (2011)	• Define AoP overcoming the conflict between societal and individual well-being
Lehmann et al. (2011)	• Device a method to deal with opposing results for different social issues (weighing based on stakeholder priorities and indicators ranked by intended users could be a solution)
Reitinger et al. (2011)	• Define AoP to be able to protect autonomy, freedom and fairness of human well-being in a coherent way
Jørgenson et al. (2012)	• Determine system boundaries covering the contradicting interests of stakeholders directly/indirectly affected in the product life cycle
Parent et al. (2012)	• Identify key problematic areas in product life cycle to improve enterprise behavior
Jørgenson et al. (2013)	• Define LCSA to better cover how product life cycles affect poverty and produced capital • Analyze the claim of LCSA technique of adding three individual results (ELCA + SLCA + LCC)
Valdivia et al. (2012)	• Integrate SLCA into LCSA for regular decision support
Benoit-Norris et al. (2014)	• Enhance social hot spot analysis covering complex supply chains to enable informed decision making
Mathe (2014)	• Integrate participatory approach into SLCA to make sense of different stakeholder context
Anke et al. (2015)	• Develop indicators and define a framework to characterize social impacts for geographically specific/regional context
Ekener et al. (2016)	• Refine SLCA methods to identify and assess positive impacts • Develop methods to aggregate with negative impacts and derive overall results

Note: Some of the limits/future research needs were overlapping but mentioned only once in the table above to avoid repetition.

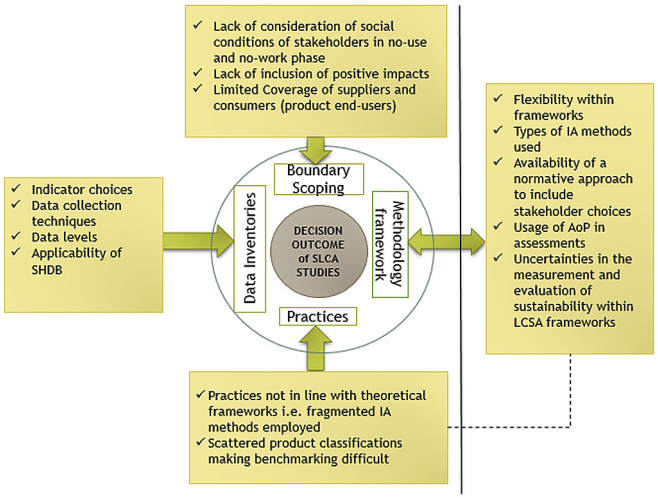

Fig. 1. Factors influencing the decision outcomes of SLCA studies.

stakeholder oriented (e.g. Participatory, validity of impact pathways); some are part of sustainability assessments (e.g. LCSA). Area of Protection (AoP) (e.g. what is being protected in the SLCA methods) are also described. These are further detailed in Section 4.1.

Boundary setting refers to the scope of the SLCA studies reviewed. The system boundaries used (e.g. cradle to gate, gate to gate); choice of subjective indicators, inclusion of supply chain actors and customers, consideration of positive impacts and inclusion of consequences of decision while setting boundaries and how all this influences the results are all further detailed in Section 4.2.

Data inventories refers to collection of data, techniques followed to collect data, types of data employed, social hotspots database (SHDB) and the kind of indicator choices made. These are further discussed in Section 4.3. Though indicator choices are also relevant under the IA, in this work they are described under data inventories, as the need for data collection is to represent them in the form of interpretable indicator units without any manipulation (Garrido et al., 2016).

Practices refer to the industrial/real world applications of SLCA. Though very few case studies were employed by authors to test the applicability of their developed methods, the aim of those studies was to primarily develop a methodology protocol. While for the studies described under this section, the primary aim of the study was a product/process evaluation in a sectoral application using SLCA and many authors have developed their own methods to suit the needs of the product/decision maker's requirement. Various product applications of SLCA; new research tools employed (e.g. AHP, Preston curve, BAMES tool) are all further detailed in Section 4.4.

4.1. Methodology framework

The existing methodology frameworks in SLCA literature were analyzed from a decision support perspective and five key factors were identified, that affect the decision outcome when these frameworks are used: (1) Flexibility within frameworks; (2) Types of IA methods used; (3) Availability of normative approach to incorporate stakeholders' choices in assessments; (4) Uncertainties in the definition and evaluation of sustainability used in LCSA frameworks and (5) Usage of AoP in assessments. The most agreed upon factors and some key discrepancies existing among different frameworks are detailed under these sub-sections.

4.1.1. Flexibility within frameworks

The stakeholders and sub-categories considered as well as the indicator choices made for assessing social impacts are up to the discretion of the users/researchers/authors. This gives flexibility for decision-makers to make their choices and decide what should be considered for assessment. Though these choices are made based on the objective of the study to some extent; it makes comparison and reusability of the method difficult (Chhipi-Shrestha et al., 2014). Different studies have used different characterization models, weighting factors/methods making standardization of the developed methods more difficult or impossible and simultaneously makes employing the developed frameworks for decision making in real world applications more complicated as the results from the studies are not fully comparable because of the flexibility within the framework even for the same sector. Methods have to be developed with the case studies as the base; generalization and rules have to be drawn from many case studies; whereas in SLCA it is the other way around, the frameworks are developed and are adopted according to the needs of the users which is influenced majorly by data collection to carry out product evaluation, all this increases the risk (reduced accuracy of results) of the developed methodological framework when employed for decision making in practice (Baumann et al., 2013).

4.1.2. Types of IA methods

Type 1 and Type 2 are the two impact assessment approaches used in SLCA. The literature neither clearly promotes one over the other nor indicates that the choices made may affect the results. However, reviews conducted in these topics reflect that the choice between Type 1 and Type 2 methods is made currently based on the characterization models and indicators available (Parent et al., 2010). A well-documented link established in the form of impact pathways between the social impacts of a product and its effect on AoP is the key for accurate results enabling informed decision support, however this is absent in Type 1 IA methods, which appears to be the most used IA technique within SLCA currently. The need to document multiple impact pathways between damage category and impact category could be a reason for less usage of Type 2 assessments (Weidema, 2005). The same reason can be attributed for fewer number of indicators and sub-categories included in Type 2 methods. Some notions associated with Type 1 methods like, consideration of norm based PRPs and focus on company activities alone have already been addressed to some extent in the new approaches by considering stakeholders' judgment/average performance within the sector, hence the absence of causality based characterization factors is the only baseline difference that distinguishes Type 1 from Type 2 IA methods (Garrido et al., 2016). Hence, when a better understanding of causality chains at company level is developed using some innovative approaches (e.g. theory of change in social return or investment approaches) it can most likely remove this existing difference between these two types (Garrido et al., 2016). Simultaneously, within Type 1 methods it is essential to understand the definition of PRPs, it should be a threshold, benchmark or an ideal value which enables comparison with the current indicator values. Consequently, when a user makes a choice between these 2 methods for IA, it may not affect the results/decision outcomes of the study in future.

4.1.3. Availability of normative approach to incorporate stakeholders' choices into IA

Stakeholders are the key players in SLCA and promoting improvement of the social conditions of the stakeholder is the ultimate goal of SLCA (Jørgensen et al., 2012). However, there is no normative approach in literature for integration and choice of

stakeholders in IA methods in SLCA currently. Mathe (2014) proposed participatory approach (adaption of Principle, Criteria, Indicator (PCI) method) that enabled various factors like stakeholder interests, local knowledge and impact categories that could be considered while choosing Stakeholders for assessment. If the result of an assessment is not merely to inform the final score or result but help in decision making, then Stakeholders' opinion must be integrated into the IA methods and the stakeholder selection criteria must essentially consider involvement stage, roles attributed to the Stakeholders and participation significance (Mathe, 2014). Moreover, importance of each social impacts may be felt differently by different stakeholders hence confirming the importance of the context within which the impacts arise is important (De Luca et al., 2015). Stakeholder commitment throughout the process and issues when employed for comparative purposes are the challenges of this approach. This kind of approach also simplifies search of indicators in the next step.

4.1.4. Usage of AoP in assessments

One of the earliest mentions of what is worthwhile to be protected in an SLCA evaluation was encountered in Norris's endpoint SLCA, in which human health was configured as the central point of evaluation, followed by Dreyer et al. (2005) whose work also emphasized and human health, dignity and well-being as the focus of SLCA studies. Hence there is definitely an endpoint or central element called AoP and protecting the same should be the aim of all social evaluations. This definition of what to protect will help to assess how much a product or its manufacturing organization exerts on the activities of a products chain and eventually on the central element (Dreyer et al., 2005). In other words, when the central element of protection is defined, then it is much easier to evaluate the impacts exerted by the product/organization on the central element, failing which the results of the study (decision outcome) may become weak. However, what are the different AoPs considered in existing frameworks and how to choose one is an ongoing discussion.

AoP in existing SLCA methods

Most methods in the literature do not exhibit much clarity in this part and have not explicitly mentioned the AoP in the goal of the study except a few mentioned below. Jorgensen et al.'s work in which there is a clarity between human well-being and societal well-being from an individual and social perspective using impact pathways. Feschet et al. (2010) considered human well-being of the present and future generation and stated well-being as a function of different stocks of capitals. Brent's work (Brent and Labuschagne, 2006) considered internal human resources, external population, macro social performance and stakeholder participation as AoPs. The AoPs (what and how much of the social criteria must be assessed to protect the affected stakeholders) used in Brent's work were chosen after a complete analysis of the SLCA guidelines and CSR literature to understand the existing usage of social criteria. Brent's work also emphasized when organization also has to be included as the central element then the AoP has to be chosen after analyzing a few social criteria like: social responsibility of a company towards its employees, responsibility of company's operational activities on the society, contribution of an enterprise towards environmental and financial performance of a region and relationship between company and all its stakeholders (Brent and Labuschagne, 2006). Hutchins and Sutherland's work (Hutchins and Sutherland, 2008) considered human health, safety, equity and quality of life. Consideration of future generation, human capital, equity and financial performance can be attributed to the fact that Feschet, Brent and Hutchins' work are all related to SLCA within sustainability assessments.

Overall, it is reflected that, there is no explicit mention of AoP in most cases, however stakeholder/human well-being is implicitly stated by the authors in few cases. Within human well-being new dimensions like autonomy, freedom and fairness was considered in Reitinger et al.'s (2011) work while De Luca et al., 2015 work related human health to not only health and safety but also economic viability and freedom of choice and quality of the environment in which he lives. Feschet et al. (2010), stated that, researchers mostly assessed human well-being without considering the society in which he evolved and its attributes. UNEP guidelines also defines AoP as endpoints that define societal values. Some authors also state that, social impacts/issues occur mainly due to the organization/company than the individual processes/stakeholders involved (Dreyer et al., 2010a; Martínez-Blanco et al., 2014) and well-being of the stakeholder is equally important to fulfilling the organization requirements (Lehmann et al., 2011, 2013; Dreyer et al., 2010a). In this context, varying approaches using geographic contextualization used by Dreyer et al. (2010b) (stakeholder context) and Ramirez et al. (2014) (company context) are good examples. UNEP guidelines also emphasizes major focus on organization responsibility (Catherine and Bernard, 2009) and the social condition of a stakeholder can be improved by improving the enterprise behavior (Parent et al., 2012). Now this led to a question, what is it that we want to protect when conducting a SLCA? (1) Stakeholder well-being (2) Societal well-being or Organization well-being. Generally, these three are the decision makers as well in most cases, and hence the results or decision outcome should not be biased based on the decision maker. As such, there is a lot of conflict existing in defining and choosing the AoPs with the kind of limited theoretical foundations available in literature (Feschet et al., 2010).

4.1.5. Uncertainties in measurement and evaluation of sustainability within LCSA frameworks

Absence of a clear definition of sustainability and comprehensive framework with relevant indicators are the two-major sources of uncertainties that affect the decisions derived from the existing sustainability frameworks. Feschet et al.'s (2010) sustainability framework explains that, actual well-being should be maintained for present as well as future generations to some extent, for which a minimum stock of wealth/resources is needed. This method is also characterized by maintenance of stocks of each capital (human, natural, social and produced) for the future generations like Jørgenson et al.'s (2013) method based on the Brunt land's theory. In addition to maintenance of stocks, alleviation of poverty is also a goal to be achieved for attaining sustainability and life cycle methodologies should establish a link between the 2 goals and help in assessing those (Jørgensen et al., 2013). Unlike Feschet's method that considers the differences between stocks and flow and refers to the depreciation of resources/wealth in production levels as a reduction of stocks and not as an income, Jorgenson's method focuses on what kind of services these stocks provide to increase the human welfare and what should be done to maintain them for the future generations. Clearly, Jorgensen's approach is a supplement to Feschet's approach as both highlight similar issues relating to the interpretation of sustainability, future generations, meeting basic needs and maintenance of stocks.

Hutchins and Sutherlands' method (Hutchins and Sutherland, 2008) emphasized the need for social sustainability of supply chains like Feschet's method which also insists on changing the mode of governance of supply chains by integration of social aspects in decision making. Hutchison developed indicators related to corporate social responsibility and linked them to the endpoint named human health which includes safety, equity and quality of life through impact pathways involving wages, benefits and investment. Whereas Feschet suggested that until now only

characterization and organization of indicators linking them to endpoints was being carried out and the next step was to articulate them into the multiple capital model that includes not only human, social and physical capital but also the institutional capital (norms), which would reflect whether the social impacts estimated affect or benefit the AoP (Feschet et al., 2010).

In literature, the authors' definition of sustainability varies, some include summation of environmental and social impacts alone, while others include economic impacts due to the product system (ELCA + SLCA + LCC). This balanced aggregation of three pillars of sustainability in the form of scores is quite contradictory to the theoretical foundation of sustainability (future needs and poverty alleviation) described above. However, it is also argued that only such simple representation of LCSA results can enable non-experts who are the major decision makers in most cases in the real world take a decision from these results and improve products' life cycle (Traverso et al., 2012). Jørgenson et al. (2013) in their work clearly indicated that what is the most important is to develop a framework with an objective to assess how a product's life cycle will affect the stocks and how much of it needs to be maintained for the future generations to survive.

Apart from the absence of clear definition of sustainability, Feschet et al. (2010) also highlighted some ambiguities within the existing SLCA methods when used within sustainability assessments like (1) Researchers showing a clear difference between social and economic impacts and assess them using 2 different tools SLCA and LCC respectively though guidelines confirms SLCA as social and socio − economic LCA, (2) large inventory of indicators with no proper synthesis or perspective as a consequence of social aspects being very complex and the existing theoretical methods not so explicit, (3) provides a picture of more negative consequences than positive. Consideration of hidden costs (not only direct effects), positive impacts (not only damages), and economic price (not only financial price) might reduce ambiguities in the existing models and make them more dynamic models (Feschet et al., 2010).

The usage of LCC within LCSA is not supported by Jorgenson et al. as well, as it is only relevant in assessing the income generated or used in a product life cycle. Sustainability aspects like maintenance of stock for future generation and poverty alleviation are best assessed using LCA and SLCA methods itself if the links are well-established and related indicators are developed. However, researchers use LCC for economic aspects and SLCA for social aspects individually and do not consider future generation and maintenance of stocks in their evaluation (Basurko and Mesbahi, 2014; Lehmann et al., 2013; Moriizumi et al., 2010; Stamford and Azapagic, 2012, 2014). Souza et al. (2015) in their waste management case study developed and employed a sustainability framework based on decision science concept and included stakeholder perspectives in selection of impact categories. Most importantly, unlike other LCSA case studies, in this work the social impacts created by the product system was assessed based on poverty in the present generation and maintenance of stocks for the future generation to meet their basic needs (Souza et al., 2015). Both Jorgenson and Feschet did not conclude that LCC was not relevant within LCSA but only insisted on developing LCSA that eventually matched the definition of sustainability which is meeting the needs of the future generation covering all the 4 stocks and include LCC only if income gains for the poor are assessed.

4.2. Boundary scoping

Boundary setting is very important for any SLCA study. System boundaries employed in case studies were analyzed in Petti et al.'s (2016) work and it was reported that, most of the SLCA studies have assessed single phase only, predominantly the system boundary (SB) of cradle to gate (partial) is the trend existing in the literature. Social impacts arise majorly from company conduct which makes site-specific data collection an important aspect in SLCA, however without a cut-off criterion to prioritize socially significant processes and companies it will be challenging to develop scientific IA methods (Chhipi-Shrestha et al., 2014). Factors like cut-off criterion, social issues assessed, life cycle phases assessed have all been dealt with in previous reviews, hence in this work, the focus is primarily on: whether positive impacts, consequences of non-implementing a decision are included in boundary setting? Whether usage of subjective indicators make boundary setting difficult? And finally, whether suppliers and customers are included within the scope of existing SLCA studies?

4.2.1. Usage of subjective indicators and its influence on boundary setting

Decision support using SLCA is all about measuring the consequences of a product/service. Jørgenson et al. (2010) took the example of workers' category to explain this: most of the SLCA focused on the workers' work life and how it impacted his/her well-being whereas the no-work life of workers was hardly assessed. Similar is the case with no-use phase of certain products/services. The social condition of the stakeholders in the no-work, no-use phase has to be included in the boundaries of the assessment to derive more accurate results. The non-work life experiences also control the work life of a stakeholder, Jørgensen et al. (2010) explained this with an example of workers with dissatisfied life-style and its influences on his/her work life. Hence the lives of the stakeholders like workers and consumers during non-work and non-use stage has to be assessed accurately using indicators for effective decision making (Jørgensen et al., 2010). Here again, subjective indicators that measure experienced well-being of stakeholders in such situations make boundary setting more difficult. Similarly, SLCA can be a more attractive decision making tool when positive impacts are also considered alongside negative impacts. Although aggregation of the two impacts at impact category or stakeholder level remains a challenge, weighing might to some extent help in this complex task, as it will help in understanding the severity level of the impacts on the stakeholders, however when there is no possibility of contacting the affected stakeholders, then it becomes an issue (Ekener-Peterson et al., 2014).

Positive aspects and temporary indicators to describe the potential benefits of vehicle fuels was described by Ekener-Peterson et al. (2014). Jørgenson et al. (2010) in their work described the non-implemented life cycle situation (e.g. unemployment of workers) with relevant indicators and impact categories identified from literature and empirical findings from other related fields of research. However, these are only guidelines, this kind of boundary scoping covering the consequences of a decision in a product's life cycle and inclusion of positive impacts has been avoided in almost all studies owing to cumbersome data collection requirements, choice of subjective indicators or in most cases unavailability of indicators itself except for the stakeholder worker within which unemployment is an indicator that could be assessed.

4.2.2. Coverage of suppliers and customers (product end-users)

Overall from the literature review we found that regardless of the individual aims of the different SLCA studies, the scope of the studies is weak in two portions which can affect decision making: supplier selection and customers. These two areas are not much explored, though businesses look at corporate sustainable development and build close relationships with their suppliers, the social impacts caused by the suppliers does not affect the selection process (Vavra et al., 2015). Petti et al. (2016) in their study also

confirmed that only 8% of SLCA studies assessed value chain actors and 7% consumers, proving the weak correlation that exists between boundary scoping and supply chain actors as well as customers (Petti et al., 2016). Also, many industries like chemicals, electronics do not know the social impacts on the actual end users of their products, though sustainability reports, product labelling and feedback mechanisms of the companies are available still social assessment is not carried out in most cases for the use and disposal phase (Ciroth and Franze, 2011; Vavra et al., 2015). Significant amount of ignorance of the end-user of the product is not only a threat in terms of the social impacts, but also a threat to the involved company's economic survival, this situation can be made better only by strengthening cooperation within value chain and lot of information sharing (Vavra et al., 2015). There is also an argument that the ethical basis of any IA in SLCA is the lives of people living now and in future and they are of equal values (all stake holders involved) and need not be further categorized as subcategories and indicators (Arvidsson et al., 2014; Baumann et al., 2013). However, the importance of social impacts may be felt differently by different stakeholders, hence confirming the significance of context within which the impacts arise and how it affects stakeholders individually is very essential while setting boundaries as it eventually influences the results of the study (decision outcome) (De Luca et al., 2015). The scope of studies whose intended users are not customers but the decision makers themselves (companies), must include choice of technologies used, supplier choices made and company behavior in their assessments (Lehmann et al., 2011, 2013).

4.3. Data inventories

At inventory stage, decision outcomes of SLCA studies are influenced by (1) data levels (unit process/company/sector/industry or country level) (2) data collection techniques (site specific in the form of interviews/surveys or statistics through desktop research) employed to gather data and (3) indicator choices made.

4.3.1. Indicator choices

Literature states that indicator must act as a connector between a system/product and its possible social impacts on the AoP. Also, Jørgenson et al. (2010) questioned whether the current indicators validly assess the impacts on the well-being of the stakeholder and whether incidence of child labor is a valid measure for assessing social impacts on the AoP which is human and societal well-being and enables legitimate decision making. In this context, some indicators may be important from the operational context of the business assessed, however might not be relevant in connecting the social impacts and the studied product system, which could also affect the results of the study. Context specific social indicators developed using top-down (international standards and current SLCA studies) and bottom-up approach (preferences of affected Stakeholders in the region) will guarantee an accurate assessment in regional perspectives (Siebert et al., 2016). Still a best way to include such contextual indicators in IA and make it relevant, needs to be researched (Garrido et al., 2016).

4.3.1.1. Direct and indirect indicators. Two types of indicators are being used within the SLCA literature namely direct or quantitative (e.g. number of employees below a certain age, number of working hours etc.) and indirect or qualitative indicators (e.g. training provided to workers, safety manuals for usage of machines). Almost all the studies in this review have used direct indicators except Dreyer et al. (2010b) and Aparcana and Salhofer (2013b). The company's efforts to integrate managerial measures at 3 levels are assessed using indirect indicators in Dreyer's work. Aparcana and Salhofer (2013a) proposed 3 indirect indicators along with 26 semi-quantitative indicators in their study of waste recycling systems in Peru. Indirect indicators are less used compared to direct indicators in literature currently. Though both types can be used, indirect indicators are slightly better placed as they reflect the potential impacts of a product and real complexity of issues like child labor by measuring the company performance indirectly unlike direct indicators which fail to completely represent the complexity of child labor and often depict it as impacting negatively ignoring the real-life situation of the child and his/her family (Dreyer et al., 2010b). The indirect indicators help by considering the efforts of the company towards the social well-being of the child who is working for his/her family and enable a more accurate decision without cornering child labor as a negatively impacting social aspect always.

Assessments using indirect indicators complement one made with direct indicators and simultaneously identify problems in the studied system due to the presence or absence of certain prevention policies (Aparcana and Salhofer, 2013a). For instance, alongside direct traditional quantitative indicators like number of employees below a certain age etc., indirect indicators like preventive management efforts of a company, training provided to workers, safety manuals for usage of machines, presence of a formal policy for health & safety of employees etc. Enable better evaluation of certain social impacts (Aparcana and Salhofer, 2013b). The company performance indicators related to both management efforts (indirect) and effects of the practices on the employees/workers (direct) were used in Ramirez et al.'s work (Ramirez et al., 2014).

The only drawback of indirect indicators is: its qualitative/semi-quantitative characteristic. However currently in most of the studies the data collected in the form of Yes/No answers or in any other qualitative form were transformed into numerical information making aggregation and comparison of results easy by scaling.

4.3.1.2. Subjective and objective indicators. Another distinction made between indicators within SLCA literature is its nature of being objective (e.g. wages, working hours etc.) or subjective (e.g. experienced well-being of the SH). There is also a flexibility of choosing between objective or subjective indicators for evaluation which affects decision outcomes when incorrect choices are made or when a few indicators are left out due to data unavailability. Subjective indicators need an established impact pathway that connects them to the AoP. The main drawback of subjective indicators when used in identifying hot spots in the product life cycle/supply chain specifically is that the decision makers cannot influence the subjective well-being decision of the individuals however the hot spots can be termed as potential instead of actual (Jørgensen et al., 2010). For instance, the objective life conditions of a worker can be improved by increasing salary but the decision maker's (company) link to the experienced well-being of the stakeholder is not a guaranteed change. Secondly, to measure subjective indicators, the actual experience of the affected stakeholders has to be collected in the form of data which is very site-specific and hence cumbersome. Hence subjectivity in IA especially related to companies has always been reported to impair decision outcomes.

In some product categories/sectors, the indicators proposed by the guidelines may not be applicable for a complete evaluation in life cycle perspective like the use phase of a laptop (Ciroth and Franze, 2011). The indictors are more related to company behavior like product safety or labelling and not describe how it affects the end-user (positive and negative) when used. In such cases, subjective indicators that capture the opinions of the eventual end-users (consumers) has to be taken in the form of interviews or surveys and transformed into quantifiable scores (Type

1) or linked to AoP through causal chains (Type 2). This different approach is needed to evaluate the use phase of certain products which will enable decision making when the entire life cycle of a product is considered for evaluation of social impacts. Data collection to interpret these subjective indicators like experienced well-being and establishing a link between the collected data and the products' activity that has caused is very tedious and remains undocumented in literature (Garrido et al., 2016).

4.3.2. Data collection techniques

Within data collection methods, it has been reiterated since many years that site-specific data in the form of interviews, survey or observation is the best for a holistic decision outcome. Statistics from government bodies, NGOs, company internal reports etc. Can be used as performance reference points (PRPs) in the evaluation. On the contrary, there is also a school of thought that businesses have too much reliance on site-specific reports, audits and interviews as industry associations did not publish any national data on a regular basis, availability of information ends at the company itself, lack of usage of public information sources like Eurostat, absence of branch data and historic data, all of this can make the IA a one-time decision-making process (Vavra et al., 2015). Also, site-specific data when collected for products having life cycle phases in many countries is very time consuming and tedious. Though such data collected is context specific, it is practical only when a few life cycle phases or stakeholders are considered (Chhipi-Shrestha et al., 2014). There is a lot of shortcomings in the data collected in the form of interview results from affected stakeholders, it has also been described as debatable in some studies (Fan et al., 2015). Eurostat is a generic database that chemical related businesses can use, however regular updating of national data is not available as industries do not provide information, with Czech Statistical office (CSO) as an exception which ensures processing and publishing of data to a limited level of detailing (Vavra et al., 2015). More such functions have to be developed enabling the data needs of individual industries. Companies can make use of tools such as questionnaires, site audits and think-lists to help identify and collect the appropriate information for decision-making during their supplier selection, which can be made available online as it can help researchers/practitioners in their data collection step to some extent.

Social Hotspots database (SHDB) has to some extent eased data collection at country/sector level for over 100 product categories, provides data from various supply chain actors, which is otherwise very hard to obtain (Benoit-Norris et al., 2012a, b; Norris et al., 2014). Researchers use it only to identify hot spots or key problematic areas in the supply chain of products, but overall decision outcome cannot be restricted to hot spot identification alone, comparative assertions, use stage assessments, sustainability assessments are also areas that need SLCA as decision making support tool (Jørgensen et al., 2009). SHDB can give an overview, but can it reflect the social differences and inequalities in a nation is an ongoing discussion. In this context, a few challenges faced by the researchers include: (1) absence and limited coverage of indicators is a major challenge (e.g. misleading marketing practices of a company, indicators for subcategories like labor law and collective bargaining was not available) (Zamani et al., 2016); (2) social categories and themes are generic and not product specific as well as differences in the coverage of indicators for local community and society stakeholders (Ekener et al., 2016); (3) limited coverage of impacts for "access to material sources like arable land" and "access to immaterial sources like land rights" are missing; (4) higher resolution – data has to be entered for a larger number of sectors and better precision – correctly divided into regional data (Ekener et al., 2016). Some indicators (e.g. risk of not having access to hospital bed) in SHDB have to be more transparent in order to understand how it connects a products social performance and its activities that affects the AoP, failing which usage of such indicators can lead to wrong results/decision outcomes (Garrido et al., 2016). Finally, it is recommended to use SHDB as starting point to find the key problematic areas in a products activities chain, use site-specific data in those hot spots alone and finally incorporate IA methods to derive final single scores/decisions (Benoit-Norris et al., 2012a and b).

4.3.3. Data levels

Data collected can be placed at different levels in the link between the product/system under evaluation and the AoP (Garrido et al., 2016). Some data collected directly represent the activities of the company and how they affect the product (health & safety training provided by company etc.) and some represent the experienced well-being of the stakeholder (how happy he feels; how safe he feels etc.). The former is placed closer to evaluating the social performance of the product/system; while the latter is farther placed. However, if the causality links between the stakeholder's well-being and how the product's activity has created that effect are well established then this trade-off can be avoided to some extent. For instance, for measuring the consumers' health and safety, while using an electronic product like computer, data can be collected from the consumers, but the questions used to understand the well-being of the consumers must be linked to usage of the product (e.g. sleep deprivation, body ache etc.). Similar causal links must be established between the data collected and an activity of the product that could have caused the positive/negative impact. Such documentations currently are not available in literature. However, consulting consumers is very complex and when to stop consulting is a debatable aspect (Souza et al., 2015).

This review reflects that the most used data levels in the studies are industry level, company level, country/regional level and unit process level in that order. In some studies, the country/regional level data are used as replacements for the product chain activities happening at company level, however in those cases the results are not termed as social performance but as potential social impacts or social risks (Benoit-Norris et al., 2012a, b). Similarly, different producers within a sector in a country might have differences, when these are concealed or when data at national level is used, in these situations SLCA helps identifying only potential risks and not actual impacts (Ekener et al., 2016). It is important to note that, company data are context specific and unique and cannot be extracted from industry databases and national/regional statistics or used as substitute for the same, in such studies the results derived could be misleading.

4.4. Practices

Within these case studies, decision outcomes are influenced by the following factors: (1) Fragmented IA methods employed within case studies and (2) Scattered product classifications making benchmarking difficult.

4.4.1. Fragmented IA methods employed within case studies

It is clearly evident from the review that the existing practices are not in line with the theoretical frameworks developed. A few exceptions include Foolmaun et al. (2012a and b) work of PET bottles assessment, Umair et al.'s (2015) study of informal e-waste handling and Agyekum et al.'s (2017) study on bamboo bicycle frames. Among these, IA method proposed by Ciroth and Franze (2011) was used for checking validity of their newly developed method by Foolmaun et al. and the other two for IA itself. The SHDB model based IA was carried out in 4 cases (Ekener-Petersen and Finnveden, 2013; Ekener-Petersen et al., 2014; Lehmann et al.,

2013; Zamani et al., 2016). Though the fact that, practices deviating from the theoretical frameworks/methods can be considered as an obstacle that is delaying the standardization of the IA methods and eventually better results when used in real world applications, it is also important to acknowledge the fact that the individual authors who have developed new methods for their IA assessment have explicitly mentioned the methodological deficiencies in the existing methods in their work and to some extent have tried to narrow the gaps in the existing literature (Albrecht et al., 2013; Baumann et al., 2013; De Luca et al., 2015; Feschet et al., 2013). Hence it is also useful to reflect on which aspects these newly developed methods have brought in greater clarity within decision support.

The newly developed methods are synthesized for (1) different analytical research tools integrated within SLCA in order to develop these new methods, and (2) significant contributions within characterization and weighing approaches.

4.4.1.1. Analytical research tools integrated within SLCA. Integration of other analytical research tools has been a long-standing practice in SLCA and increases legitimacy and efficacy of SLCA as a decision-making support tool (Anne et al. (2014). (1) Integration of Analytical Hierarchy Process (AHP) and qualitative research focus group used within SLCA framework that enabled public decision making as a policy maker as well as management authority proposed by De Luca et al. (2015); (2) IA method using AHP and multi-criteria decision analysis (MCDA), a model that can be used in the absence of any activity variable, proposed by Hosseinijou et al. (2014); (3) The empirical relation established between more economic activity, good income and healthy life using Preston curve proposed by Feschet et al. (2013); (4) Usage of Life cycle working environment (LCWE) within SLCA in which positive and negative impacts of a higher working hours was evaluated proposed by Albrecht et al. (2013); (5) An empirical relationship established between value of labor (working time) and value of product produced (tomatoes in this case) proposed by Bouzid and Padilla (2014); in order to highlight disparities in a company or a food chain as a whole; (6) Systematic competitive model proposed by Lagarde and Macombe (2013) and (7) Usage of BAMES Tool for SLCA by Basurko and Mesbahi (2014) in their LCSA work are all significant methods that seem to be best placed to provide better results/decisions.

4.4.1.2. Characterization and weighing models employed. Aparcana and Salhofer (2013a,b) in their study of recycling systems, Foolmaun et al. (2012a and b). in their study of PET bottles, Hosseinijou et al. (2014) in their hot spot analysis, Manik et al. (2013) in their palm oil diesel study and Nemarumane and Mbohwa (2015) in their South African sugar industry, have all employed stakeholder's perceptions/opinions collected in the form of interviews in their characterization models. Bouzid and Padilla (2014) in their tomato supply chain assessment relied on their own judgement of company's activities in their characterization approach. Manik et al. (2013) went one step ahead to weigh the social issues based on stakeholder opinions and then use an expert led weighing step to complete the weighing process. Hosseinijou et al. (2014) also employed a similar weighing step but using MCDA technique for ranking the issues. Weighing was done based on the inputs given by the users in Lehmann et al. (2013) study related to waste resource management in Indonesia. Weighing was done based on experts rating on the importance of issues in Dong et al.'s building construction model (Dong and S, 2015), in which a 5-point Likert scale was used for rating, a similar socially weighed impacts of citrus farming was carried out by De Luca et al., (2015).

Among the characterization approaches available, inclusion of stakeholder's experience/concern can be considered the most effective way as it will assess the effect on human well-being more effectively which will aid decision support eventually. Within weighing methods employed, implicit equal weighing employed in most studies might result in discrepancies in studies, all sub-categories cannot be given equal significance, each have its own weak or strong effect according to its relevance in the life cycle step. Assigning different weights to the strong and weak relation of indictors and the subcategories and further use those weights as factors for aggregation of results at sub-category level is a possible approach (Ofori et al., 2017). Garrido et al. (2016) suggests weighting inside a stakeholder category (not employed in current practices) might reflect the potential social impact of a company on its stakeholders and support decision makers to improve or stabilize. When all risks are treated equal and summed up and sometimes counted within a subcategory due to lack of data leads to unbalanced result. The decision outcome can be termed only as identification of risks due to the above limitation. Hence the weighing approaches used in the case studies based stakeholders/experts' perspectives could narrow this gap to some extent.

Similarly, scientific methods to aggregate results at stakeholder level and subcategory level is also lacking in the existing frameworks. The complicated link between one indicator and many subcategories in a SLCA framework could be a probable reason for inadequacies at the aggregation step (Agyekum et al., 2017).

4.4.2. Scattered product classifications making benchmarking difficult

Difficulties are encountered in carrying out full-fledged SLCA studies of complex products like laptop, these products include many sub-products, keep changing often due to technology, the evaluation of these products include requirements of many site −specific data which are generally confidential. Though product labelling and sustainability reports are available to some extent, still the business does not know end-user completely and the potential social impacts of the products on the well-being of the end-user (Ekener-Petersen and Moberg, 2012). SLCA studies in e-waste recycling systems, especially the informal ones are extremely difficult due to primary data requirements (Umair et al., 2015), knowing the various negative social impacts associated within the industry, extracting data from involved SH is very tough (Arcese et al., 2013). Lack of benchmarks is a major limitation within SLCA practices, which makes assessments even more challenging. It is nearly impossible to make a product classification within the case studies as the product/system/industry assessed are so much scattered. It is also difficult to make SLCA a mandatory requirement for industries as it will pave way to greater challenges, however similar to ELCA it can be hoped that in coming years as SLCA develops into a more mature decision-making tool, more case studies will be conducted enabling synthesis of results and data within individual sectors/industries. Especially, modelling of new life cycles for new products including assessments of specific suppliers and production locations can aid businesses in supplier selection for their products and comparison of product alternatives that enables buying decision for a consumer are interesting future applications of SLCA (Ciroth and Franze, 2011).

Within the case studies there is contradiction between the perceived significance of a few sub-categories and indicators and its actual usage in the IA for deriving results. The reason could be the lack of subcategories and indicators benchmarked for industries and choices are currently made according to decision makers (business/industry) objectives and data availability (Revéret et al., 2015). However, this kind of differences between

Table 2
Summary of limitations of existing SLCA studies from a decision-making perspective.

Category	Limitations
Methodology framework	• Flexibility within frameworks • More commonsense based frameworks that are not based on case study experiences • Usage of ambiguous and ideological indicators in IA • Absence of causality chains at company level to remove the difference between Type 1 and Type 2 methods • Absence of normative approach to integrate SH choices in IA • Less or no clarity in definition of AoP; conflict in defining and choosing AoP - Stakeholder well-being vs Societal well-being vs Organizational well-being • Absence of clear definition and a comprehensive evaluation of sustainability within LCSA frameworks • Usage of 2 different tools LCC and SLCA for assessing socio-economic impacts
Boundary Scoping	• Boundaries not set enough to understand the impacts exerted by the products life cycle on the stakeholders • Lack of inclusion of the consequences of non-implementing a decision (social conditions of stakeholders in no-work and no-use phase) and positive impacts • Lack of techniques to integrate positive and negative social impacts • Subjective indicators that make boundary setting difficult • Less consideration of suppliers and consumers in the system boundaries
Data inventories	• Too much reliance on interviews and surveys as data collection techniques • Lack of updates of national/industry data to be used as benchmark/threshold • Country/regional level data used as substitutions for company level data • Lack of recording of SLCA results – company use as one-time decision making tool • Absence/lack of information about raw materials and end-users • Difficulty in collecting data for subjective indicators • Lack of documentation of the link between data collected and product activities causing effects for subjective indicators • Less usage of indirect indicators and contextual indicators • Lack of applicability of indicators proposed by the guidelines for the consumer stakeholder in certain applications • Lack of universal application of SHDB including limited choice of indicators, lack of transparency of indicators, lack of data for few developing countries and new technologies
Practices	• Most fragmented usage of IA methods and product classifications resulting in making benchmarking difficult • Characterization models based on meeting norms and best practices, geographic contextualization and stakeholder's opinion don't easily co-exist. • Weighing inside a stakeholder category reflecting company performance do not exist • Lack of scientific methods to aggregate indicator results to subcategory level and stakeholder level • LCSA score derived as summation of SLCA + ELCA + LCC; concepts of sustainability like alleviating poverty, maintenance of stocks, meeting the needs of the future generation not addressed • Difference between the perceived significance of certain subcategories indicators and its actual usage

theoretical expectations and actual research results in subcategory choices could possibly affect the decision outcome of the case study (Vavra et al., 2015). Results obtained from SLCA practices, are very general at times and in most cases, do not reflect how the derived result may sometimes work against the norms and stakeholder expectations, within comparative assessments the focus is mainly on simply comparing two alternatives and derive a decision, in the process a thorough evaluation of the product system is not carried out (Garrido et al., 2016). Varying relevance of the frameworks used, data availability and practical interest of the decision maker, all these play a role in SLCA practices (Lehmann et al., 2011). Critical steps in SLCA application which can aid decision making include the correct choice of affected stakeholder, impact categories, subcategories and establishment of a taxonomic relation between them (De Luca et al., 2015). Overall, it can be concluded that applying and discussing the existing IA methods using case studies is the best way to improve them (Smith and Barling, 2014). However, in the current practices, theoretical frameworks developed are hardly being used and researchers develop own methods according to their project objectives individually.

5. Summary of limitations of SLCA studies as decision making support tools

Some drawbacks are commonly recognized that impair the usefulness of SLCA as decision making support tools. Broadly speaking, drawbacks can be classified into four major categories: (1) Methodology framework (2) Boundary scoping (3) Data inventory and (4) Practices. Table 2 lists a summary of limitation of SLCA studies from decision making perspective.

6. Conclusions

The preceding sections have highlighted the multiplicity of approaches (theoretical and case studies) that are available in SLCA literature currently. Limitations/factors that weaken the usefulness of SLCA studies as decision support tools were analyzed and broadly classified into four groups namely methodology framework, data inventories, boundary scoping and practices. This kind of analysis is useful to gain clarity on what is important to protect in SLCA, what kind of boundary setting or indicator choices made or IA methods employed, might most likely affect the result of the SLCA or decision outcome of a study. Supply chain has a major relevance in decision process, hence data requires traceability all the way back to the extraction sites from the producers. This will facilitate policy/decision makers conduct more detailed SLCA and set right criteria for product purchase and assure that the usage of a product is in line with sustainability commitment made by them. Measuring company performance is crucial as there is mostly a causal relationship between good company practices and positive social impacts. Communication and usage of results is also a crucial issue for improved decision making. Greater involvement of public will also promote decision making tools. Overall to recognize decision support from SLCA, getting experience in data collection, building a data stock, integrate the IA methods into a software and

finally find ways to effectively communicate and use results in the market are the crucial factors.

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