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SOCIAL LCA IN PROGRESS

Preface

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Several efforts have been made in the last 10 years to improve and further implement social life cycle assessment (S-LCA)[1] methodology, which, among the three life cycle techniques, is the least developed and not standardized yet (UNEP/SETAC 2013; UNEP/SETAC 2009). Developments occurred in many directions, ranging from aggregation methods for social indicators, definition of system boundaries, data collection, and building up of S-LCA databases, just to name a few. In parallel with the methodological developments, industries and private organizations started applying S-LCA and developed it further by tailoring the method to the specific needs of the sector of interest. However, for confidentiality reasons, these applications are not publicly available yet. And also, because S-LCA results are difficult to communicate due to two main aspects: the method is still under development and improvements are needed, an aspect that hampers the robustness of the results themselves, communication, if not done properly, can lead to misunderstanding by the final users/consumers.

For this reason, it is time to make a reflection about where S-LCA is going, which purposes and goals it can serve, what is currently available and how it can be used, and how organizations could benefit from it. These considerations led to the development of this special issue titled "Social LCA in progress" to highlight the evolutionary nature and status of S-LCA.

As expected, the themes of the special issue touch on many critical topics currently debated on S-LCA in the scientific community. We grouped them into four main themes:

- The variety of approaches in S-LCA: four papers acknowledge the variety of approaches of S-LCA and three other papers attempt to explain this apparent variety from the history and the background of the method.
- Robustness in S-LCA: robustness is always a relevant issue when it comes to engineering methods. Three papers interrogate the rigor of S-LCA, either as a whole or only related to the design of system boundaries.
- Improvement for type I* S-LCA: seven papers highlight routes for improvements, regarding goal and scope, cutoff criteria, inventory of performances, impact assessment, or other complementary methods, to improve quality of the social analysis. The main goal of five other papers is checking if S-LCA type I is coping with different implementation grounds.
- New impact assessment for type II*[2] S-LCA: seven papers are suggesting methods to perform impact assessment for type II S-LCA, with the ambition of proposing generalizable findings.

The choice of the main topics was carried out by giving more importance to the increase of generalization (which is one of the goals pursued by science) than to the implementation of case studies alone. We are aware that other ways to partition the papers would be possible.

[1] "Social life cycle analysis" may be abbreviated under the form either S-LCA or SLCA depending on the author.

[2] *Type I and type II S-LCA are described in Parent et al. (2010).

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1 The variety of approaches in S-LCA

The huge number of approaches to implement S-LCA can confuse newcomers. This variety is indicative of both the vivacity and the newness of this research domain and led the scientific community often to develop a state-of-the-art review to define the main developing paths of the methodology.

The attention of Arcese et al. (2017) (State of the art in S-LCA: integrating literature review and automatic text analysis) is devoted to elaborate, by lexicon analysis, a general classification of the approaches in a systematic and reproducible way. The results showed a rapid succession of different topics covered in the analyzed period; out of which, four topics are explaining more than 60% of the variation: (1) use of generic terminology; (2) S-LCA is company-oriented (has to be integrated with other decision tools); (3) S-LCA is stakeholder-oriented (willingness to integrate stakeholders in its development); and (4) underlines what is specific to S-LCA.

Gathering all types of S-LCA approaches, Di Cesare et al. (2017) (Positive impacts in social life cycle assessment: state of the art and the way forward) set out 47 papers containing theoretical frameworks and 46 papers presenting case study to a perform a systematic review in order to analyze the types of indicators adopted. A quarter of the theoretical papers take into account the topic of positive impacts. Results from case study analysis highlight that "workers" were the most considered stakeholders (in 100% of the analyzed papers) and that the majority of "positive indicators" used in the case study are recorded in relation to "other value chain actors."

Petti et al. (2017a) (Systematic literature review in social life cycle assessment) performed a systematic review of case studies implementing S-LCA between January 2009 and May 2015 and retained 35 papers, whose 50% were published in the present journal. Fifty-six percent regarded a product (mainly in "food" category), 41% studied a service, and 3% analyzed a process. Manufacture and agriculture are the most investigated sectors, followed by energy. In general, the cases analyzed appear to be linked with strong environmental stakes, more than with high-risk social issues.

Russo-Garrido et al. (2017) (A literature review of type I SLCA—making the logic underlying methodological choices explicit) performed an analysis of the diversity of approaches of type I SLCA, whose assessment generates a result located at the same point as the inventory data, with regard to the impact pathway. An important contribution is the identification of the differentiating factors among type I S-LCA, which lies in "what the inventory data is assessed against" at the characterization step and how it is ultimately weighted. In addition, they bring to light a relevant typology of six characterization methods and five types of weighting.

Sakellariou (2017) (A historical perspective on the engineering ideologies of sustainability: the case of SLCA) explains the diversity of approaches in S-LCA by its "hybrid" origin between (in a nutshell) engineers and social scientists. In other words, S-LCA is the arena gathering partisans of engineering innovation and partisans of socio-cultural change, who believe that engineering needs to be socially and politically contextualized.

More specifically, Hobson and Lynch (2017) (Ecological modernization, techno-politics and social life cycle assessment: a view from human geography) often discover the "ecological modernization (EM)"[3] theory in the worldview of authors, when exploring S-LCA's underpinning assumptions. The paper argues that debates around EM resonate with many of those in S-LCA, but the linkages between EM and S-LCA approaches are not identical depending on the approach. The authors claim that it would be worth to "excavate the epistemological genealogies of the various approaches to S-LCA."

That is exactly the task undertaken by Iofrida et al. (2017) (Can social research paradigms justify the diversity of approaches to social life cycle assessment?) who track the roots of S-LCA diversity in the cultural and scientific heritage of social sciences and especially management sciences. The authors set the hypothesis that the diversity of positions in epistemology in social sciences would result in the diversity of worldviews by authors of S-LCA, especially in its beginnings. Therefore, for the advancement of S-LCA, the authors point out the need to strengthen this awareness and the theoretical bases of S-LCA.

2 Robustness in S-LCA

Grubert (2017) (Rigor in social life cycle assessment: improving the scientific grounding of SLCA) is searching methods in social sciences for developing rigor in S-LCA. She shows that data collection can benefit from using social science frameworks for surveys and interviews. She identifies social impact assessment (SIA) and corporate social responsibility (CSR) outputs like empirical data sources for S-LCA. The author advises to use impact allocation techniques close to the ones used in environmental life cycle assessment (LCA) and highlights that further grounding in social science is likely to improve rigor in S-LCA.

With the same concern about rigor, Macombe et al. (2017) (Extended community of peers and robustness of social LCA) identify the main weaknesses of S-LCA from operation research definitions. Is it worth to rely on a community of peers to make the S-LCA study more robust? It is possible, under some conditions to be met, the most of them concerning the role of the consultant/researcher conducting the case study.

[3] «The EM framework forwards social change via incremental and institutional interventions that promote continued development and privileges objectivity, impartiality, and the search for a totalizing knowledge of the impacts of good and services" (Hobson and Lynch, in this special issue).

After two papers addressing several aspects of robustness, Dubois-Iorgulescu et al. (2017) (How to define the system in social life cycle assessments? A critical review of the state of the art and identification of needed developments) focus on the tricky issue of rigor in setting the boundaries. The authors scanned 33 papers (published between 2009 and 2015). The findings are especially relevant because they analyze the conceptual view of each author as a whole. Finally, they highlight two approaches (often coexistent): one is technical, defining life cycle stages in terms of technical processes related by material or energy flows, and the other is socio-economic, selecting organizations as system units. When implemented, cutoff criteria are chosen according to the objectives of the assessment, the targeted audience, and the methodology chosen to conduct the S-LCA.

3 Improvement for type I S-LCA

Seven papers are eager to present routes for improvement of type I S-LCA, aiming at different steps.

Zanchi et al. (2017) (Analysis of the main elements affecting social LCA applications: challenges for the automotive sector) analyzed how the key elements affecting the inventory phase of S-LCA applications have been dealt with, with the ultimate purpose of identifying and developing a structured approach to S-LCA. They have organized the most important elements affecting the goal and scope definition, and inventory phase of S-LCA into a conceptual map, to help practitioners in the application of S-LCA. The authors implement their own advices in the case study drawn from the automotive sector.

Zamani et al. (2017) (Hotspot identification in the clothing industry using social life cycle assessment—opportunities and challenges of input-output modelling) pay attention to the cutoff rules to define the boundaries. The authors implemented a cradle-to-gate, input/output-based S-LCA, using Swedish clothing consumption as a case study. Social indicators are selected by consumers from the Guidelines. They underpin that the cutoff rules affect the results because of the number of country-specific sectors included or excluded in the analysis.

Four papers (Fontes et al. 2017; Ekener et al. 2017; Petti et al. 2017b; Valente et al. 2017) mainly focus on the inventory and implementation steps.

Fontes et al. (2017) (Product social impact assessment) pursue the goal of consolidating principles for the level of product/service social assessment, in accordance with the main literature available and with industrial strategies on social impacts. They report the work by the "Roundtable for Product Social Metrics."

Ekener et al. (2017) (Addressing positive impacts in social LCA—discussing current and new approaches exemplified by the case of vehicle fuels) seek ways to improve the methodology of the Guidelines regarding systematic identification of all potential positive impacts in the supply chain. In accordance with the case study of vehicle fuels, the paper suggests to divide the Guidelines' subcategories in positive/negative impacts and to add some other positive impacts. It also suggests to categorize the indicators in four levels according to their potential to achieve positive impacts.

Drawing experience from the case study of an Italian tomato, Petti et al. (2017b) (An Italian tomato "Cuore di Bue" case study: challenges and benefits using subcategory assessment method for social life cycle assessment) suggest improvement for the complementary subcategory assessment method (SAM) in the case of agricultural products.

Valente et al. (2017) (Testing environmental and social indicators for biorefineries: bioethanol and biochemical production) tested the Social Hotspot Database (SHDB) targeting workers, for two biorefineries located in USA and in Norway. For Norway, more detailed bottom-up investigation of an existing Norwegian biorefinery value chain confirmed some of the risk issues but discarded others, demonstrating the necessity of providing context-specific data (here, thanks to interviews) for the social dimension.

The improvement of a quantitative implementation of S-LCA and its interpretation step is the aim of Traverso et al. (2017) (Towards social life cycle assessment: a quantitative product social impact assessment), when implementing a product social impact assessment for a certain car tire. The method is the quantitative implementations of the product social impact assessment developed by the Roundtable of Product Social Metrics. The method use 26 indicators split between three groups of stakeholders. The reference values for interpretation (by a distance-to-target approach) are defined by setting ideal or worst case target scenarios.

The five papers by Sousa and Cauchick Miguel (2017), Souza et al. (2017), Pelletier et al. (2017), Fan et al. (2017), and Siebert et al. (2017) pursuit the purpose of both addressing improvements of type I S-LCA and proving whether the respective S-LCA method presented is fitting in their field. Indeed, thanks to S-LCA, they seek to perform the social analysis of: product-service systems, sugarcane biotechnologies from Brazil, EU trade risks, green residential districts, or territories.

Sousa and Cauchick Miguel (2017) (The main challenges for social life cycle assessment (SLCA) to support the social impacts analysis of product-service systems) aim at investigating the applicability of S-LCA to the social impact analysis of product-service systems (PSS). The PSS are innovative approaches that shift the business focus from selling physical products to selling services that are capable of fulfilling consumers' needs. The main results pointed out that only a few indicators in the Guidelines could be used for PSS analysis. Additional research is still needed before S-LCA is capable of accounting for social impacts of PSS.

For Souza et al. (2017) (Social life cycle assessment of first and second generation ethanol production technologies in Brazil), the main goal is to suggest quantitative social metrics to evaluate different sugarcane biorefinery systems in Brazil by exploring a novel hybrid approach integrating S-LCA and input-output analysis. The study results pointed out the usefulness of the hybrid approach in distinguishing the social effects over different present and future sugarcane biorefinery supply chains.

Pelletier et al. (2017) (Social sustainability in trade and development policy) assess social risks associated with trade-based consumption in EU member states. They performed a macro-scale analysis by combining statistics with data from the Social Hotspot Database. The apparent social risk profiles of EU imports have then been assessed based on (a) consideration of country-of-origin social risk data (non-life cycle-based approach) as compared to (b) a life cycle-based social risk assessment which also took into account the distribution of social risk along product supply chains. Both analyses provide quite different results. The injury and fatality risk indicator is more important relative to the other risk indicators in (a) analysis. Estimated risk is nonetheless proportionately larger across all other indicators in the (b) analysis. Certain risks are only visible when a life cycle approach to quantifying risk is employed.

Fan et al. (2017) (Evaluation for social and humanity demand on green residential districts in China based on S-LCA) are intended to establish a quantitative evaluation method for social humanity needs of green residential districts, based on the Guidelines. To get magnitude of social performances, they complemented inventory with questionnaire survey to develop a scoring system and gave weighting of the different indicators by experts. It is important to underline that it is necessary to conduct weight analysis in every evaluation for each project, because experts have different concerns, depending on the project.

Siebert et al. (2017) (Social life cycle assessment: in pursuit of a framework for assessing wood-based products from bioeconomy regions in Germany) aim at developing an S-LCA framework that can be applied to a wood-based production system in one of Germany's bioeconomy regions. They develop a new conceptual framework for a context-specific S-LCA that combines indices and indicators about globally relevant social sustainability aspects (drawn from international sustainability standards and from current S-LCA approaches). With a bottom-up approach using national sustainability strategies and regional strategies, while introducing the interests and preferences of the affected stakeholders, it enables S-LCA practitioners to identify "social hotspots" and "social opportunities" from a regional perspective and their locations.

4 New impact assessment for type II S-LCA

For the sake of clarity, the seven papers of this session are further sorted into three groups: (1) two papers addressing ad hoc pathways for particular ground. Despite its interest, this work does not lend to generalization; (2) three papers developing general pathways, each treating certain types of impacts, and which might be implemented on many different grounds; and (3) two papers which deal with general reflections involving type II S-LCA.

The first paper dealing with specific pathways is authored by Pizzirani et al. (2017) (The distinctive recognition of culture within LCSA: realizing the quadruple bottom line) who developed bespoke (ad hoc) cultural indicators to include cultural issues in determining a range of forestry land use and product options. The interviewed Maori people explain the likely impacts of different forestry practices on different cultural issues. As envisioned, the causal relationships building the pathways cannot be generalized, but the method based upon interviews is general.

It is the same conclusion for the paper authored by Wangel (2017) (Back to basics—the school lunch) who suggests a research design to support consumers in making choices, e.g., alternative school lunch scenarios, according to their subjective social and cultural values. Inspired by "reverse LCA," the assessment is performed as an action research by the community of stakeholders involved and using an interactive scenario analysis. Three preliminary school lunch scenarios were evaluated by stakeholders in terms of valuable functioning for human well-being.

The three papers developing general pathways all constitute a major breakthrough in type II S-LCA. They are authored by Arvidsson et al. (2017), Weidema (2017), and Touceda et al. (2017). The pathways are dealing respectively with the following impacts: human health; income inequality and loss of productivity by missing governance; and health of workers, health of households, and prosperity.

Arvidsson et al. (2017) (A method for human health impact assessment in social LCA: lessons from three case studies) suggest a new method for assessing human health impacts within S-LCA, inspired by three previously conducted case studies (Airbag, Catalytic converter, Gold jewellery). The idea is to sum positive and negative impacts, all being expressed in DALY. The impact assessment methods are drawn from LCA, from the "work environment" method (relying on knowledge from the field of occupational health and safety) and from the "assessment of conflicts" method (conflict and development studies).

Weidema (2017) (The social footprint—a practical approach to comprehensive and consistent social LCA) presents an original and promising approach. The author argues that it is possible to focus on the relatively few impacts that dominate in global importance; in general, they are income

redistribution and productivity impacts of missing governance (loss of productivity and/or loss of well-being). Direct productivity impacts include missing education, trade barriers, underemployment, corruption, and lacking physical infrastructure, while loss of well-being can be valued in terms of productivity including health impacts, lacking social infrastructure, and ecosystem and heritage impacts. These impacts are quantifiable from national statistics without a need to access detailed technology- or enterprise-specific data.

Touceda et al. (2017) (Modeling socioeconomic pathways to assess sustainability: a tailored development for housing retrofit) are searching for characterization models in S-LCA, resulting from the identification, combination, and adaptation of available methods, developed within various research fields. These methods analyze damages to the health of workers involved in the life cycle and to the health of the household living in the retrofitted dwelling. Impacts on human well-being and dignity are addressed by analyzing prosperity, in terms of fair employment, alleviation of fuel poverty of households, and economic growth.

The two papers dealing with general reflections about S-LCA are very diverse. Mancini et al. (2017) sort out E-LCA and S-LCA by the nature of the flows they handle, rather than by the nature (environmental or social) of the calculated impacts. McCabe and Halog (2017) deepen the difficult issue of the modeling of cause-effect relationships. In some complex cases, asking directly the actors seems to be the only one solution.

Mancini et al. (2017) (Characterization of raw materials based on supply risk indicators for Europe) attempt calculating new characterization factors (all including supply risk factors calculations) in LCA for accounting for resource security. They define the concept of resource criticality as gathering environmental, economic, and socio-politic dimensions and deliver an original reflection about the nature of LCA and S-LCA. Indeed, they explain that they "would therefore define LCA as a methodology assessing the impacts (of environmental, economic or social nature) due to environmental interventions along a supply chain, i.e. due to the extraction or emission of physical substances, while social LCA and life cycle costing base their assessment on non-environmental flow exchange (e.g. value and working hours)." These new definitions call for careful attention and will likely entail new debates.

McCabe and Halog (2017) (Exploring the potential of participatory systems thinking techniques in progressing SLCA) highlight the potential application of participatory modeling approaches as a potential entry point in understanding impact pathways and system behavior in S-LCA. This inclusion will improve interpretation and is especially relevant if enhanced consideration of stakeholders' values is desired. It is a privileged mean to capture dynamic non-linear cause-effect chains that are common in social systems.

5 Take-home messages

The papers presented in this special issue are of the utmost interest to progress in S-LCA, both from a methodological and a practical perspective. Collecting the different approaches proposed and further reflecting on them, we would like to summarize their contribution in the following take-home messages:

- Social impact pathway vs social performance: both impact pathways and performances are needed in S-LCA, as they provide different level of information that can both support the decision process. The relevance of social impact pathways is about their ability (within the limits of their conditions of use) to anticipate future states, while the follow-up of social performances over time allows monitoring the development of the situation. For users, it is important to identify the different use cases.
- Theoretical bases of S-LCA: the diversity of approaches, in S-LCA like in other life cycle-based methods, has been considered so far as a hindrance to method uptake and use. However, we should not forget that, depending on the question at hand and on the paradigm chosen, different approaches are indeed needed. So, diversity is not a drawback but its recognition is a starting point for moving forward. The very stake for researchers is taking a clear stand whatever the theoretical position is. About users, they need to acquire knowledge in order to be able to choose the kind of method which is relevant to solve their problem.
- System perspective in S-LCA: while developments are needed at the level of single methodological issue, such as system boundaries, cutoff, and characterization in impact assessment, just to mention some, however, they have to be dealt with not in isolating but in considering their mutual interrelations. In fact, one ideal "S-LCA" method should coherently deal with all the issues faced by LCA: system definition, boundary setting, sources of data and inventory, rules for interpretation, characterization in impact assessment, etc. We therefore warn the users not to mix parts of methods rooted in different perspectives.

Before concluding this preface, we would like to underline why the methodological developments exposed here are important, rather than appearing as mere quarreling among experts. The resources which the researchers have are limited. They must choose which ones carry their effort first and foremost. Yet, behind the choice to develop such an approach hides different visions of the world, and even different political choices (in the sense of the choice of management of the city). Does this require choosing between development and

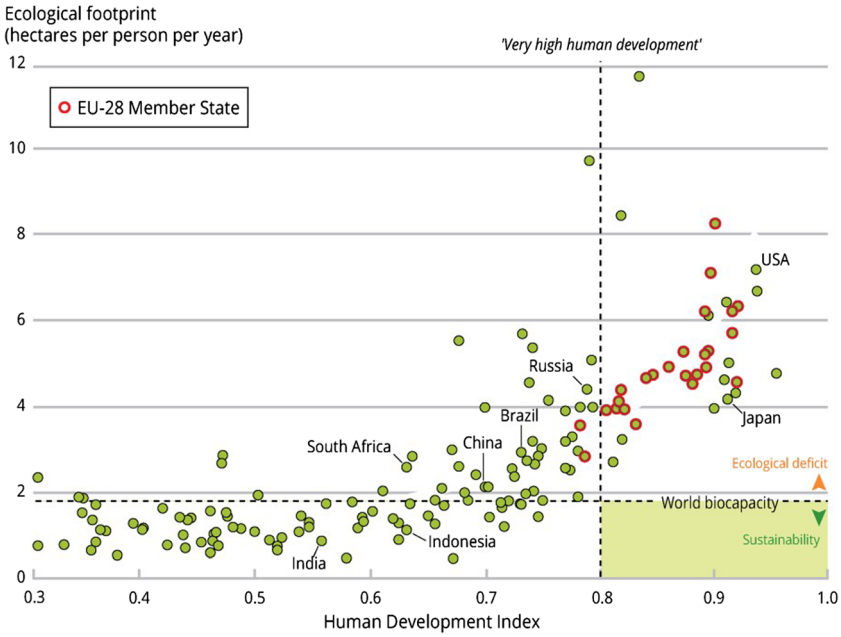

Fig. 1 Human development index and ecological footprints of nations—source: Global Footprint Network (2012), UNDP (2014)

diminution? To be quick or to take its time? What scale to take into account? For what purpose?

The reason why the social valuation methods are important is that the current human societies manage very rarely to reconcile on a large-scale natural environmental protection and social development. The curve connecting the index of human development and the ecological footprint of nations reminds us (Fig. 1). The human societies in which we live achieved, for some, remarkable social levels of development. However, until now, it is to the detriment of the natural environment, whereas the environmental impacts which are low or moderated show extremely reduced social development. Taking place in the rectangle in the right lower corner of Fig. 1 is the "grail" which should be the aim for all nations. Although occupying a minor place among the macroeconomic valuation methods, LCA and S-LCA methods can play a role at this scale. Nonetheless, it is especially within the companies that they often constitute a relevant decision-support tool, because they encompass the good's «value chain» in the life cycle design.

Note: The human development index is calculated using three components: education, life expectancy at birth, and wealth. It is expressed as a value between 0 and 1, from less to most developed countries. The ecological footprint measures how much land and water area a population requires to produce the resources it consumes and to absorb its waste. The world biocapacity is the global productive area available on earth (it decreases as population grows). https://www.eea.europa.eu/soer-2015/global/setting-the-scene

Companies play a major role in the challenge. Certain ones already understand that to last, they need (i) to be profitable, (ii) to produce with the lowest ecological footprint as possible, and (iii) to deliberately provoke favorable social impacts. Hence, companies need to know the environmental and social impacts of their choices. Separating environmental and social impacts—as we have done in this special issue—is only justified in the case of building new assessment tools. To detect adverse effects, the impacts have to be assessed with reliable, robust, and modest[4] methods. The life cycle analysis methods are not THE solution, but they provide an often relevant contribution to mitigate the sustainability issues in value chains.

We therefore invite the readers and practitioners worldwide to read the papers and to get in touch with the authors for fruitful new exchanges and to further strengthen interdisciplinary collaboration to further enhance S-LCA and to make it a robust decision-support method.

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[4] About the necessity of modesty in LCA approaches, we underline that the study of «rebound effects» (which evade current LCA methods) is absent from this special issue, whereas it is a social and research major issue.

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