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Social Life Cycle Assessment for agricultural sustainability: comparison of two methodological proposals in a paradigmatic perspective

Keywords: Social Life Cycle Assessment, citrus growing, agricultural sustainability, impact pathway, participative techniques

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The purpose of the present research is to provide an explanation about the diversity of methodological approaches proposed until today for SLCA, tracking down its roots in the cultural and scientific heritage of social sciences, especially sociology and management sciences. This will help to shift the current methodological debate in SLCA to an epistemological level, through a critical review about the underlying paradigms that have been applied in SLCA literature until now. Secondly, the research highlights the possible consequences of different paradigmatic stances in SLCA by means of the application, to an important agricultural sector in Calabria, of two different methodological proposals set up from opposite paradigms (post-positivism and interpretivism) and compared in terms of research process and typology of insights.

1. Introduction

Social Life Cycle Assessment (SLCA) is the latest tool developed in the conceptual framework of Life Cycle Thinking (LCT) and is devoted to the assessment of social impacts generated by the life cycle of a product or service (Zamagni *et al.*, 2016). The methodology is not standardised as it is for its environmental and economic peers, i.e. Life Cycle Assessment (eLCA or LCA) and Life Cycle Costing (LCC). Indeed, there is neither consensus about the impact assessment methods, nor clarity on the underlying social sustainability concepts. Consequently, many different methodologies have been proposed, whose objectives payed attention to different aspects (Jørgensen, 2013; Iofrida *et al.*, 2016), such as:

- the social performances (UNEP-SETAC, 2009; Franze and Ciroth, 2011; Martìnez-Blanco *et al.*, 2014; Mattioda *et al.*, 2015; Hannouf and Assefa, 2017);
- the presence of hot-spots (Benoît-Norris *et al.*, 2012; Dong and Ng, 2015);
- the consequences of a change in life cycle (Feschet *et al.*, 2013; Bocoum *et al.*, 2015);
- externalities (Swarr, 2009);

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- and the stakeholders involvement (Mathé, 2014; De Luca *et al.*, 2015b).

Even in the definition of SLCA there is no consensus; indeed it has been defined at the same time as: a a systematic process (Benoît *et al.,* 2010), a framework (Benoît-Norris, 2012), a technique (Benoît Norris *et al.*, 2012; Ugaya *et al.*, 2011), a technology (Fan *et al.*, 2015), a method – not a technique – (Macombe *et al.*, 2011), a phenomenon (Benoît-Norris and Reverét, 2015).

This plethora of methodological proposals in SLCA is probably due to its development in the engineering milieu of eLCA, which led practitioners to deal with social impacts in the same way they were used to do with environmental impacts in eLCA (Iofrida *et al.*, 2016). However, the inherent nature of environmental and social impacts can be strongly different: in fact, SLCA and eLCA have their roots in different fields of study and disciplines (O'Brien *et al.*, 1996; Iofrida *et al.*, 2016). While environmental phenomena are the object of study of natural sciences, social phenomena are the object of study of sociology, that not only has a variety of methodological approaches to research, but also it is considered a multiparadigmatic science (Corbetta, 2003), in which even many realities can exist according to the perception of stakeholders. According to Iofrida *et al.* (2016), this implicitly had consequences in SLCA too.

Concerning the main field of application of SLCA studies, according to a recent review by Petti *et al.* (2016), manufacturing and agriculture are the most assessed sectors. For more information about the SLCA applications in agriculture, see for example De Luca *et al.* (2015a) and Gulisano *et al.* (2018). The typology of actors concerned can vary according to the typology of study, such as a population (Feschet *et al.*, 2013; Bocoum *et al.*, 2015), children (Arvidsson *et al.*, 2015), but workers are the most assessed category above all. UNEP-SETAC (2009) Guidelines proposed 5 possible stakeholder groups to evaluate, namely workers, local community, society, consumers and value chain actors. However, no information is provided about how to clearly distinguish them, and most of the procedural choices remains at discretion of the researcher.

In SLCA literature, it is difficult to outline a general common procedure for the assessment of social impacts. Following De Luca *et al.* (2015a), the different methodologies can be distinguished according to which are recognised as sources of social impacts, e.g. the very nature of processes, actors' behaviours, variations of capitals, stakeholders' desiderata. The "impact pathway methodology" is epistemologically similar to eLCA (Weidema, 2006; Norris, 2006; Feschet *et al.*, 2013; Macombe *et al.*, 2013; Neugebauer *et al.*, 2014; Bocoum *et al.*, 2015). This typology of impact assessment procedure evaluates the consequences of a change in the life cycle of a product or service, explained in terms of cause-effect relationships (Iofrida *et al.*, 2016). The principal aim of this methodology is to provide explanations and generalizable findings.

UNEP-SETAC (2009; 2013) published the "Guidelines for SLCA" and the Methodological Sheets to furnish a practical framework to assess performances of a system at a current status. The Guidelines boosted the publishing on SLCA themes, especially applicative works. In the Guidelines it is suggested to follow the same general structure of eLCA (ISO, 2006a; 2006b), i.e. the four phases of "goal and scope", "life cycle inventory", "life cycle impact assessment", "interpretation of results". They provide an orientative list of indicators inspired to international laws and norms on human rights. The assessment framework in the Guidelines is mainly inspired to the above-mentioned Corporate Social Responsibility (CSR), therefore, the applications published according to this framework mostly paid attention to the social performances of companies in terms of companies' behaviours.

The "capabilities or capacities approach" (Reitinger *et al.*, 2011) is inspired to the work by Sen (2000), and takes into account the capabilities (set of alternative lives) that people can choose, and it is focused on what people consider to be important for their lives (Iofrida *et al.*, 2016). Within this framework, Garrabé and Feschet (2013) proposed a model to assess the variations of capital stocks (human, technical, financial, social and institutional capitals) due to the functioning of the life cycle and their influence on people's capacities (Iofrida *et al.*, 2016).

Finally, some other approaches have put more attention on what is important for stakeholders (intended as those actors interested by the functioning of the life cycle) and how to involve them in the assessment (Mathé, 2014; De Luca *et al.*, 2015b).

The reason of this methodological diversity is here tracked down in the scientific and cultural heritage of the disciplines linked to SLCA, i.e. sociology and management science. Indeed, the object of evaluation of SLCA are social impacts (social phenomena), that are also the object of study of sociology; furthermore, LCT tools are devoted to the support of decision-making process in management practices (De Luca *et al.*, 2015a). A brief review highlighted which paradigms have been applied in SLCA literature. Then, two methodological proposals from opposite paradigms have been applied to the same case study, i.e. citriculture in Calabria (Italy), and compared in terms of research processes and typology of insigths.

2. The scientific roots of SLCA and social research paradigms

2.1 The disciplinary fields of SLCA

The nature of the impacts under assessment are different in SLCA from eLCA, and these methodologies have their roots in different fields of study

and disciplines (O'Brien *et al.* 1996). Both methodologies have been conceived to solve management issues towards more sustainable practices. However, the impacts assessed in eLCA are typically the object of study of disciplines such as biology, physics, chemistry, etc., that belong to the realm of natural sciences (also called "hard sciences"); on the contrary, social impacts are the object of study of sociology. Both sociology and management science belong to the realm of social sciences and are therefore *multiparadigmatic* sciences characterized by an epistemological eclecticism, being social phenomena multilayered events (Corbetta, 2003). Indeed, while the post-positivism philosophy dominates and is well accepted in scientific research of natural sciences, in the history of social sciences it is difficult to recognise a dominant paradigm shared by all scientists. Several epistemological positions are possible in these disciplines, tending to two main opposite paradigmatic positions: post-positivism and interpretivism.

2.2 Main families of paradigms in social and management sciences: post-positivism and interpretivism

The concept of paradigm as a set of theoretical beliefs and methodological techniques is not new in social research (Iofrida, 2016); Kuhn (1962) gave notoriety to this term describing as "normal science" the period when a scientific community consensually shares a paradigm. Despite the critics received by Kuhn, the concept of paradigm still remains up-to-date and preserve its centrality in the meta-research debate of social sciences and management sciences (Thiétart, 2014; Iofrida, 2016; Iofrida *et al.*, 2016).

A paradigm consists of three elements (Tab.1): the researcher's conception about the nature of reality (ontology), the relation between the knower and what is under study (epistemology), and how the researcher can find out knowledge (methodology) (Guba and Lincoln, 1994). These elements are strongly interrelated, and together guide the design, planning and implementation of the research (Iofrida, 2016). The methodology is the formalization of the epistemological position into practices, and shapes methods design for data gathering and analysis. Corbetta called "the delicate phase of operationalization" (Corbetta, 2003: 4) the bridge between theory and practice, the passage from hypotheses to concepts, indicators and variables. A wide number of paradigm exists but, as the lines between paradigms are often very fine, Table 1 reports two principal families of what can be considered the opposite poles to which almost all paradigms tend, comparing them in the light of their main components, i.e. ontology, epistemology, methodology and quality criteria. The aims of the two families of paradigms can be very different in terms of re-

Tab. 1. Main Families of scientific paradigms in social sciences

	Positivism-oriented	Interpretivism-oriented
Ontology: *What is reality?*	Critical realism. One objective reality probabilistically apprehendable.	Relativism. Subject and object are dependent. Realities are about perceptions.
Epistemology: *How do you know?*	Dualism researcher-research. Replicated findings are probably true. Explanation of reality.	Knowledge is interpreted. Reality can be understood and described.
Methodologies: *How do you find it out?*	Nomothetic, mainly quantitative. Experimental or statistical analyses. Probability sampling.	Hermeneutical, dialectical. Mainly qualitative methods. Stakeholders' perceptions.
Goodness or quality criteria.	External validity, verifiability. Statistical confidence level.	Intersubjective agreement and reasoning reached through dialogue.

Source: Guba 1990; Guba and Lincoln (1994); Girod-Séville and Perret (1999); Lincoln *et al.* (2011); Hesse-Biber and Leavy (2011); Phoenix *et al.* (2013); Iofrida *et al.* (2016).

search process, objectives, results obtained. Positivism-oriented paradigms are almost value-free and look for objectivity and generalisability of cause-effects relationships, while interpretivism-oriented paradigms are devoted to the in-depth description of the values and significances of social phenomena.

In the light of these considerations, a critical review of scientific literature on SLCA has been implemented in the following section, to retrace which epistemological positions have been applied and to highligth which consequences they had at practical level. A deepened analysis can be found in Iofrida *et al.* (2016).

3. Shifting the debate to an epistemological level

3.1 Scientific paradigms in SLCA literature: a critical review

To highlight which paradigms have been applied in SLCA literature, a critical review has been conducted on studies gathered with the help of on line scientific databases and research engines, by means of specific keywords (within article title, topic, abstract, keywords), and Boolean operators (AND, OR, NEAR). All scientific literature about the assessment (and synonyms) of social impacts in a life cycle perspective were included. From the first population of 209 works, grey literature, short papers and reviews were excluded. As a result, 78 scientific works have been selected, and a classification matrix has been developed.

Studies were classified according to the following criteria: identifiers, typology of literature, field of application, research paradigm applied, methodologies applied SLCA (alone or in combination with other assessment tools), impact assessment method (impact pathways, UNEP-SETAC guidelines, participative methods, capabilities/capacities approach, multicriterial decision analysis, etc.). Among these criteria, impact assessment methodology is a question of utmost importance in life cycle oriented tools, and the principal source of diversity in sLCA proposals too; therefore, it has been the core criterion to classify the literature gathered. However, as the methodological features alone are not sufficient to disclose which paradigm is underlying the research (Iofrida, 2016), an assessment grid has been set up to check and verify the presence of topical elements (literal criteria) that helped to attribute papers to one or another family of paradigms. These literal criteria are keywords and sentences providing information about the typology of indicators applied, the reasons behind their choice, the source of impacts, the priority given to the generalizability or to the local specificities, the degree of stakeholders'involvement, etc. (Iofrida *et al.*, 2016).

Results showed that 78% of the selected studies could be ascribed to the group of interpretivism-oriented paradigms, only the 21% can be ascribed to the post-positivist ones, and 1% of studies presented characteristics of both families. These data deserve some attention, because since the beginnings of SLCA, most of the scholars supported the idea that the same assessment perspective of eLCA should be applied to social impacts (Hunkeler 2006; Chhipi-Shrestha *et al.* 2015).

3.2 Strength and weaknesses of paradigms and methodological consequences for SLCA

Each paradigms family has its strengths and weaknesses (Tab. 2). Papers belonging to the post-positivism oriented group provided a smaller range of impact categories, focusing only on few social aspects, but furnished explanations of the cause-effect relationships between inventory data and impacts. This could allow predicting which changes would be suitable in life cycle management to obtain more sustainable results and impacts. The most applied impact assessment methods were impact pathways and capacity/capabilities approaches.

Papers belonging to the interpretivism-oriented group provided a broad assessment of several impact categories, furnishing a complete description of a situation at a certain moment at a certain time. Very often, they involved stakeholders at different points of the research process, such as the choice of

Tab. 2. Strength and weaknesses of the opposite families of paradigms

	Post-positivism-oriented paradigms	Interpretivism-oriented paradigms
Strength	Context free	Rich in meaning and values
	Generalizable	Holistic
	Value-free, objective	In-depth investigation
	Affordable and quick	Comprehensive understanding
Weakness	Reductionism	Context-bound
	Poor in values	Subjective
	Simplification	Long and costly
		Weak in generalizability

Source: Iofrida (2016); Iofrida *et al.* (2016).

what is worth assessing (impact categories), the choice of the most relevant indicators, or scoring tasks to discriminate the importance of results. They often took into account the experience of privileged witnesses, as well as the expertise of local actors, thus performing a more coherent context-based assessment. Most of this kind of evaluations focused on performances at a specific temporal moment, and referred, among others, to UNEP-SETAC (2009) guidelines and methodological sheets, or the Social Hotspot Database. Both realism and relativism can be suitable for social impacts evaluations, but the choice should be done in accordance to the purposes of the studies and with the awareness that results can differ in terms of significance.

In this pre-scientific phase of SLCA development, it is of utmost importance to shift the academic debate to an epistemological level in order to solve methodological problems about indicators and impact assessment methods in a coherent way.

4. Comparison of two methodologies from opposite paradigms

4.1 Field of application: citrus growing in Calabria region

Citriculture is an important resource of Italian economy, representing 3% of national agricultural Gross Saleable Production (GSP) (Scuderi, 2008). According to the last agricultural census by ISTAT (2012), the overall surfaces cultivated with citrus fruits are approx. 128,921.07 hectares in 2010, mostly concentrated in the South, especially Sicily (as first national producer) and

Calabria, that together represent 82% of national citrus production. More in detail, Sicily is the principal producer of oranges and lemons (65% and 89% of national production, respectively), while Calabria is the first producer of clementines (60% of national production) and small citruses (61% of national production, especially bergamot and cedars). In the period between the last two agricultural census (2000-2010), ISTAT (2012) highlighted a general decrease, in Italy, of the surfaces cultivated with citrus fruits (-3%), while the tendency has been the opposite in Calabria, where the regional citriculture surface increased a 10%, with a peak of 24% in the province of Cosenza.

Actually, in Calabria most of agricultural surfaces is occupied by olive growing that, with 55,955 hectares, represents the most cultivated crop and interests 34% of UUA (Utilised Agricultural Area). Among permanent crops, citrus growing is the second most important in terms of surface, accounting for 35,185.3 hectares in 2010 (ISTAT, 2012). Furthermore, 9,005 ha (about 25% of citrus growing areas) are conducted according to standards of organic

Tab. 3. Citriculture surfaces and farms in the five Calabrian provinces (2010)

	Total citruses	Orange	Clementine and hybrids	Other citruses	Mandarin	Lemon
Surfaces (ha)						
Italy	128,921.1	79,551	20,916.3	4,548.3	8,481	15,424.5
Calabria	35,185.3	16,257.74	12,530.83	2,792.27	2,984.77	619.69
Cosenza	13,229.77	3,269.89	8,664.31	253.36	695.39	346.82
Catanzaro	3,523.52	1,982.44	853.06	231.45	402.97	53.6
Reggio C.	14,853.71	8,801.53	2,224.84	2,134.98	1,505.9	186.46
Crotone	1,408.33	1,036.19	153	50.69	161.49	6.96
Vibo V.	2,169.97	1,167.69	635.62	121.79	219.02	25.85
Farms (n.)						
Italy	79,589	57,724	12,996	5,308	15,083	19,389
Calabria	20,974	14,148	6,002	2,158	3,823	1,354
Cosenza	6,987	3,321	3,889	373	1,037	663
Catanzaro	1,552	1,317	266	102	487	74
Reggio C.	10,306	7,711	1,493	1,525	1,827	459
Crotone	862	758	63	64	159	32
Vibo V.	1,267	1,041	291	94	313	126

Source: data elaboration according to ISTAT (2012).

farming practices (De Luca *et al.*, 2014). However, in terms of average standard production, expressed in € $farm^{-1}$ $year^{-1}$ and calculated as the total value of standard productions divided per the number of farms, citrus growing shows the best economic performance compared to other agricultural sectors (ISTAT, 2012). The highest value is registered by the farms in the province of Catanzaro, and the lowest by the farms in the province of Reggio Calabria. On the land used for citrus growing, 12,530.8 hectare clementine and hybrids are grown, which represents about 60% of national production (ISTAT, 2012), reaffirming the importance of this product at regional and national level. Citriculture is concentrated in flat areas near the coast, in the provinces of Cosenza and Reggio Calabria, both in terms of hectares and number of farms. In Sibari Plain's citriculture, in the province of Cosenza (CS) about 12,381.35 hectares are dedicated to citrus growing. The area is specialised in the production of clementine: about 70% of the regional production is concentrated there, and most of the clementine productions (795.4 in Calabria) are labelled with the Protected Geographical Indication (PGI), as disciplinated by the Commission Regulation (CE) 2325/97. Gioia Tauro Plain's surface, in the province of Reggio Calabria (RC), is occupied by 11,201.778 hectares of citrus growing; here, citriculture is specialised in oranges, half of which was destined to industrial processing for the production of juices until the last decade (De Blasi and De Boni, 2001). The European reform of the Common Market Organization (COM) of fruit and vegetables (Reg. (EC) 1182/2007) has been suddenly put into force without any transition period. This entailed a reduction of citrus production that have been 2,691.2 thousands of tons in 2008/2009, i.e. 926,000 tons less than the previous year, of which 856,000 tons of oranges (92%) (Source: CLAM data 2014, courtesy of CIRAD Montpellier); moreover, a decrease occurred in the number of Producers Associations (PA) that once gathered the product both for fresh consumption and for processing, thus guaranteeing the existence of an end market.

This led to a further worsening of an already weak Calabrian citriculture and its supply chain. Indeed, according to the study by De Blasi and De Boni (2001), the structure of the citrus-growing already in the early 2000 lacked of profitability and competitiveness of the products, oriented more to quantity than quality (more in Calabria than in Sicily) which was intensified by the low-level of bargaining power available to producers when dealing with the processing industries.

Since decades, there are many well-known social issues linked to the Calabrian agriculture, especially concerning the harvesting task and the involvement of foreign illegal workers. When the economic effectiveness of a productive system decrease, often the solution assumed is cutting the costs, and labour is the first cost item accounted. Seasonal migration is concentrat-

ed to the main citrus growing areas, the Plain of Sibari (CS) and the Plain of Gioia Tauro (RC) in particular. Following the report by Osservatorio Placido Rizzotto (2012), the main social issues concerning migrants are working and housing exploitation, irregular labour employment, fraud and deceit for non-paid wages and outstanding labour contracts, illegal recruitment of day labourers, requisition of documents.

According to grey literature on the theme, and interviews to privileged witnesses conducted in 2014, in the only Plain of Gioia Tauro, in the town of Rosarno and surroundings, arrive every year more than 3,000 migrants to be employed in citrus harvest. Not always the supply of work meet the demand. The presence of such a massive number of people that live in poor condition due to low wages (often clandestine and so, without access to many social services) impacts local population and sometimes creates tensions as it has been the case of Rosarno revolt in January 2010, when an increased immigration unfortunately coincided with a decreased citrus production (Paciola, 2012).

4.2 A post-positivist perspective. An impact pathway methodology: psychosocial risk factors

Decent work in agriculture has been the first goal of international organizations such as ILO (International Labor Organization); indeed, many conditions can threaten the safety of agricultural workers, in terms of ergonomics, exposure to hazardous products, diseases, and psychosocial risks. Concerning these last, one of the most diffused definitions describes psychosocial risks factors (PRF) as "those aspects of work planning and management – and their relative social and environmental contexts – that can potentially lead to physical or psychological damages" (Cox and Griffiths, 1995: 69). The methodology here applied is based on the works by Silveri *et al.* (2014) and Gasnier (2012). Their studies proposed a new methodology to predict damage to health of workers (involved in the life cycle) caused by psychosocial risk factors at work.

The paradigmatic stances underlying this first application are post-positivist. Indeed, the methodology is based on cause-effects relationships validated by previous empirical studies available in literature that provided an explanation of causes by their effect (induction), and whose results are verifiable, confirmable and refutable. These statistical relationships are expressed in odds ratios, and allow explaining the impact pathway that link the product life cycle to possible health risks in a quantifiable and probabilistic way.

The present impact pathway methodology is applied to two citrus growing scenarios: the agricultural life cycle phases (i.e. from cradle to gate) of oranges for industries and clementines for fresh consumption in two fictitious farms

of Gioia Tauro Plain (province of Reggio Calabria), with the same agricultural surface (3 ha), duration (40 years), and farming management (conventional).

The methodology is divided into the following four steps:

- an inventory analysis of working hours needs for each task (e.g. tillages, pruning, harvesting, phytoyatric treatments) and for each agricultural phases;
- a literature review about the association between particular working conditions and psychosocial risk factors expressed in odds ratio, a statistical measure of the intensity of association. Odds ratios have been classified in classes of association intensity in weak (1< OR <1.3), moderate (1.3< OR <1.7), strong (1.7< OR <8) (Iofrida, 2016).
- the construction of a PRF Matrix (Appendix Tab. A.3), where every working condition occurring in the scenarios is linked to a physical or psychosocial disease.
- the assessment of social impact through the quantification of working hours that potentially expose workers to one or more diseases.

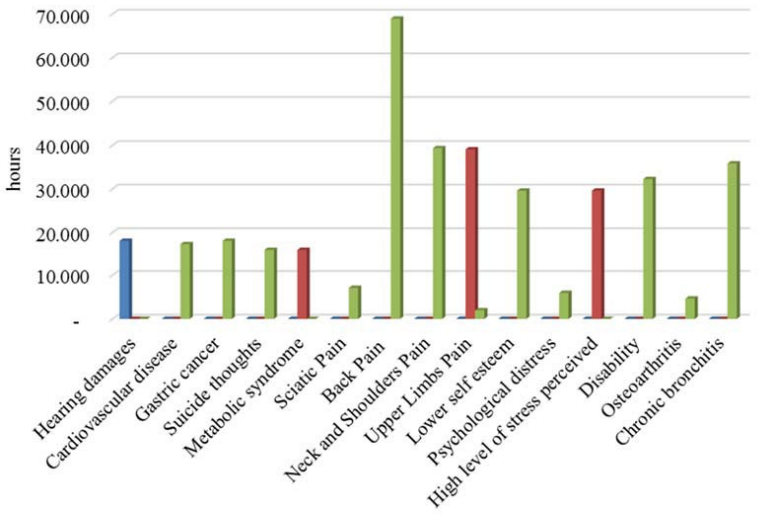
Results (Fig. 1) showed that the agricultural phases of industrial oranges life cycle entails 58,120 hours of work with exposure to the risk of chronic bronchitis (strong association), 42,510 hours of work exposing to risk of back pain (strong association), and 28,562 hours of work exposing to risk of upper limbs pain (moderate association). The agricultural phase of clementines life cycle entails 68,916 hours of working tasks exposing to the risk of back pain (strong association), and the risk of neck and shoulders pain (39,334 hours with strong association) and upper limbs pain (39,060 hours with moderate association).

4.3 An interpretivist perspective. A local based, multicriterial and participative proposal

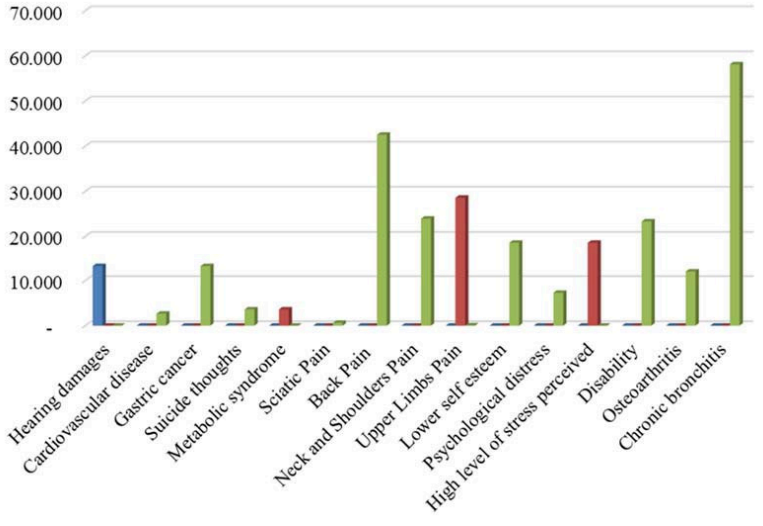
The paradigmatic stances of this second methodological proposal are interpretivist, so it is assumed that subject (researcher) and object (research) are dependent and that knowledge is interpreted through the participation of relevant actors. Many procedural choices have been at discretion of the researcher or those actors whose perception were considered important.

Nine scenarios of clementine production are compared, deriving from three main agricultural areas (Sibari Plain in the province of Cosenza, Lamezia Terme Plain in the province of Catanzaro, and Gioia Tauro Plain in the province of Reggio Calabria), and from three techniques of cultivation: organic (O), integrated (I) and conventional (C). The methodological frame-

Fig. 1. PRFs of clementine (a) and orange (b) growing scenarios



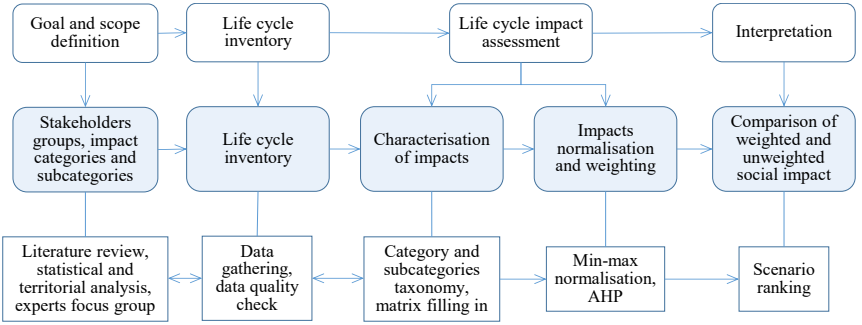
a)



b)

Source: Iofrida (2016).

Fig. 2. Interpretivist methodological framework

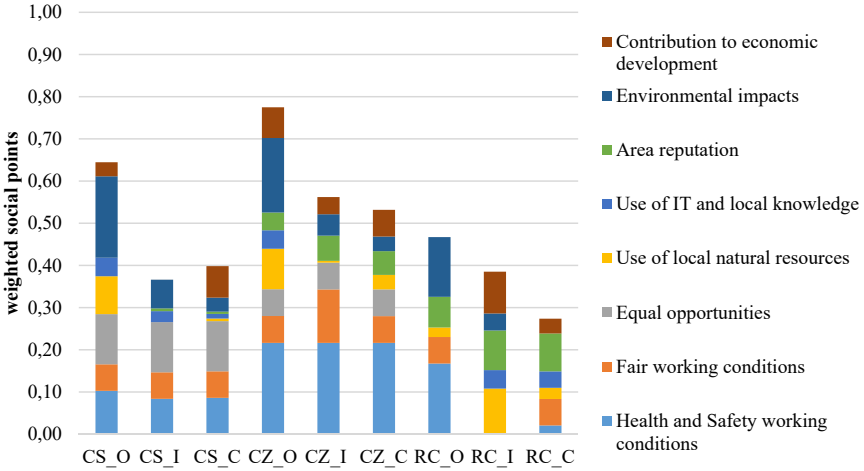


Source: De Luca *et al*. (2015b: 385).

work follows the work by De Luca *et al.* (2015a) and is graphically represented in Figure 2.

The first step of the methodological framework consisted in territorial analyses and a literature review on the main issues of the areas analysed; focus groups with local experts were implemented to choose impact categories, subcategories, and indicators. The second step concerned the inventory analysis: indicators have been calculated to complete the Social Impact Matrix (SIM) (De Luca *et al.*, 2015b). Data were collected from both primary (interviews) and secondary sources (on line databases); most of the environmental and economic data were taken from the results of previous LCA and LCC analyses of the same case study (Strano *et al.*, 2013). The third step - the life cycle impact assessment – consisted in the homogenisation of inventory data (in a positive direction) and the normalisation. The Analytic Hierarchy Process (AHP) (Saaty, 1990) was applied as a multicriterial tool to involve three groups of affected actors (workers, local communities, society from the three areas under study) in the evaluation of the relative importance of each impact category and subcategory. The forth step consisted in the application of the set of weights and the interpretation of results. Participation played a key role to make the assessment legitimate and adherent to reality. Normalisation allowed the comparison between indicators of different nature, thus offering a first ranking among scenarios in terms of (unweighted) social performances. Impacts dimensions, expressed in "unweighted social points", are the result of minimised negative data and maximised positive data, and, therefore a higher score represents a more socially sustainable performance. Results (Fig. 3) show that the organic production of Lamezia Terme Plain ("CZ_O") is the best scenario, followed by that of Sibari Plain ("CS_O") and the integrated production of Gioia T. Plain ("RC_I").

Fig. 3. Scenarios ranking with the application of local weights



Source: De Luca *et al*. (2015b: 393); Iofrida (2016).

Considering the three sets of local weights obtained from the application of the AHP, few differences result in terms of ranking among scenarios; indeed, once again the "CZ_O" and "CS_O" are the best scenarios (Fig. 3), but followed by "CZ_I". A further overall ranking elaborated from a unique set of weights (regional preferences) showed that organic growing is the most socially sustainable.

5. Discussion

The two methodologies have been very different in terms of research procedures, epistemological assumptions, and methodological choices. They furnished different typologies of results that can have different usefulness according to the context they are applied.

The first methodology applied in this study, i.e. the PRF impact pathway, was framed in the realm of post-positivism paradigms, and allowed to quantify the cause-effect relationship between citrus life cycle and psychosocial impacts on affected workers. It allowed assessing objectively the differences between two productive scenarios, and the methodology resulted to be generalizable and applicable to other contexts. It was limited to only a group of affected actors (workers), but it would be possible to extend the study to other stakeholders. Furthermore, extending the methodology to a whole sector, it would possible

to predict the social consequences also in terms of social welfare, public health and the socio-economic repercussions for a wider group of stakeholders. The principal strength stayed in the possibility of predicting the consequences of managerial or structural changes in the life cycle. Decision makers can find, in the PRF matrix, a valuable instrument to support decision, both at farm level and in the context of policy making. Furthermore, this methodology is in line with the current state of the art of environmental Life Cycle Assessment, based on cause-effect relationships between inventories of matter and energy flows and impact categories. Many scholars advocated for the development and improvement of Life Cycle Sustainability Assessment, intended as the harmonisation of eLCA, LCC and SLCA. The impact pathway methodologies well serve this aim of unification, being framed in the same paradigmatic perspective.

The interpretivism-oriented SLCA methodology (participative SIM) applied in this study mixed quali-quantitative techniques and multicriteria analysis tools allowing the recognition of local specificities by involving local experts and affected stakeholders. The practice of combinig multicriterial methods with life cycle tools has being adopted since a long time, allowing to manage subjectivity in a scientifically way (De Luca *et al*., 2015c; De Luca *et al*., 2017). Despite its local character, the entire methodological framework can be adapted to other agricultural processes and to further supply chain phases, but system boundaries and the choice of impact categories should be revised and adapted to the new context. The value added of this methodology stays in the legitimacy given by stakeholder participation and their opinions that have been used to assess impacts. Furthermore, negative and positive impacts have been taken into account, and assessment practices that have been poorly applied until now in SLCA studies. The paradigmatic perspective underpinning the methodology is in line with the state of the art of SLCA literature, as demonstrated in the critical review of scientific literature.

Concerning the research phases, Table 4 compares the two methodological proposals. As it shows, points of difference can be outlined since the beginning of the research processes, i.e. in the formulation of research question: the first one looks for explanation (*Erklären*, typical of nomothetic sciences), the second for comprehension (*Verstehen*, typical of idiographic sciences[1]) of social impacts; the same dichotomy can be found between the two main families of paradigm of sociology and management science.

The choice of case studies are similar in some terms, because based on available information and knowledge about the actual situation of Calabria ci-

[1] The terms *Erklären* and *Verstehen* comes from the discussions inside the German historicism, but have been used in many sociological debate contexts (Iofrida, 2016).

Tab. 4. Comparison of research processes of the two methodologies

PRF impact pathway	Research phases	Participative SLCA
Post-positivism. Realist and objective posture.	1. Paradigm choice	Interpretivism. Relativist and subjective posture.
Which are the real social impacts caused by the functioning of citrus life cycle? Which changes should be made to improve it?	2. Formulation of research question	How assessing social impacts on a wide range of actors affected (positively and negatively) by citrus growing? What is worthwhile protecting and for who? Who is responsible for what? Which typology of farming practice is more socially sustainable?
A transformation is occurring in Calabria citriculture: oranges for industry are disappearing in favour of quality products, e.g. clementine.	3. Choice of case study and planning	Clementine is the most renowned citricultural product from Calabria. Three main areas of production (CS, RC, CZ) and three typologies of farming practices (O, I, C).
Review of scientific literature. Data triangulation with few interviews to privileged actors.	4. Data collection	Review of grey and scientific literature, databases consultation, direct surveys and interviews.
Data gathering, classification and calculation.	5. Data analysis and impact assessment	Data gathering, normalization, and weighting according to stakeholder preferences, calculation.
The risk of Back Pain is stronger in clementine growing, but chronic bronchitis is weaker. Management changes would improve working conditions and reduce the exposure to risk of health troubles.	6. Interpretation and use of results	Organic farming practices are socially preferable. Environmental impacts and working conditions are the greatest concern among local actors.

Source: Iofrida (2016)

triculture; the same sources have been used, i.e. literature and statistics (e.g. ISTAT, 1012; INAIL, 2013).

Data collection, at the contrary, has been very different. In the first case, it was limited to literature review among medical journals, and triangulation served to select and verify the pertinence of the PRF chosen to the case study. In the second methodology, it has been a long and costly process in terms of time and costs. Many displacements were necessary for interviews that also took time according to the typology of actor interviewed: for example, foreigners (and relative problems of communication), or actors that have no information about citriculture issues. In addition, data gathering from available database was a quite long task, due to the differences of levels among them and relative adjustments needed (e.g. local vs regional data). This entailed also the construction of proxy indicators to adapt data to the case study.

Data analysis and impact assessment took the same efforts in terms of time, just a little longer in the second case due to the calculation and application of stakeholders' preferences.

In these two last points of research process (phase 4 and 5 in Tab. 4), the posture of the researcher was different. In the second methodology, the intervention of researcher into the analysis and the assessment was stronger and the personal expertise on the field of application was necessarily involved. On the other side, it was a personally enriching experience, and it showed how it is necessary to inform actors about research topics and findings and to cooperate and listen to them: at the end, they are the final addressees of research, not only academics.

The interpretation of results served different aims, as different were the starting questions. The first methodology focused only on a typology of actor, i.e. workers, but allowed to predict the effects of life cycle changes, such as the disappearing of industrial oranges citriculture in favour of clementine citrus growing. The second methodology furnished a wide description of different typologies of social impacts (or rather "performances" according to Parent *et al.*, 2010) and different actors. Furthermore, results from previous available LCA and LCC studies have been used for some indicators in the same methodological framework. However, it is not totally possible to predict which effects would occur by means of life cycle changes.

According to the analysis of paradigms in SLCA, in Table 5 the characteristics of each impact assessment are checked. By comparing them, and according to what discussed until now, it is possible to find the same strength and weaknesses of each family of paradigm in the two methodological proposals.

In both methodologies, the choice of impact categories (or health diseases in the first methodology) influenced the results. Maybe results would be different if considering more categories or different issues. As already said, there is many place for further developments and improvements.

Tab. 5. Comparison of the two impact assessment methodologies

PRF matrix	Yes ✓ No ✗	Participative SIM	Yes ✓ No ✗
Dynamic indexes/indicators to assess a status change	✗	Static indexes/indicators compared to international standards or national laws	✓
Cause-effect relationships and causal chain	✓	Participation, stakeholders involvement through qualitative methods	✓
Direct relation between process flows and impact pathways	✓	Choice of impact category according to the claims of interest groups, public acceptability, actors opinions	✓
Social impacts are intended in the same way as environmental ones in eLCA	✓	Companies behaviour regarding international norms on social issues	✗
The researcher do not need to have a direct contact with affected actors, research process is not influenced by personal opinions	✓	The researcher is directly involved in the research process, as the principal responsible of procedural and category assessment choice	✓
Access to national and international databases and statistical hypothesis testing	✗	Direct contact with affected actors (interviews, surveys)	✓
Deterministic account of life cycle causal variables	✗	Social values, actor meanings and companies behaviours	✓
Effects prediction, modelling, quantification as priority task to be assumed	✓	Qualitative scoring, social acceptance	✓
The study can be based on the same inventory data used for LCA and LCC	✓	Qualitative and quali-quantitative indicators are preferred	✓
All impacts can be quantitatively linked to a functional unit	✓	Company performances and behaviors are considered the principal source of impacts	✗
Social consequences on people lives due to a life cycle change	✗	The context specificities have strong repercussions on the assessment results	✓
The importance of generalizations and universal laws is emphasized	✓	Findings can assume a different meaning according to the context	✓
Results allow to predict a future situation	✓	Results allow to describe a current state or based on historical data	✓
Long term consequences are accounted	✓	Short term assessments	✓

Source: Iofrida (2016); Iofrida *et al.* (2016).

6. Conclusion

The aim of the study was not just to compare results, but to compare the research processes that led to the development of each methodology. The first aim of the study was to demonstrate that the methodological diversity that characterised SLCA literature is due to the influences of the scientific and cultural heritage of the disciplines assumed to be linked to SLCA, i.e. social sciences. Secondly, the study tried to answer the question if different paradigms can coexist in SLCA. Finally, the general aim was to push the academic debate from a methodological level towards an epistemological one, which has been lacking until now in SLCA. The disciplinary roots of SLCA have been tracked down into sociology and management science, and the multiparadigmatic characteristics of both have been outlined, describing the main difference of the two opposite possible paradigmatic positions (post-positivism and interpretivism). SLCA has been critically reviewed in search of which family of paradigms were mostly applied. Results provided an interesting information: the 78% of selected studies applied an interpretivist perspective. However, many scholars affirmed that SLCA should address social impacts evalutation in the same way eLCA does for environmental ones (that would mean in a post-positivism perspective).

Two methodologies have been proposed starting from opposite paradigmatic perspectives. Both provided interesting results and have been compared in terms of validity and usability.

Coming back to the main research question, the methodological diversity of SLCA literature can find a justification in the multiparadigmatic characteristics of sociology and management science, in which SLCA is rooted. That there is place in SLCA for different paradigms, it is an empirical evidence, as showed in the critical review and in the case study.

The scientific goodness of the SLCA methodology is of utmost importance when the purpose of the analysis is for economic or political decision-making processes. Both families of paradigms are scientifically valid, but the objectives can be different and therefore can serve different purposes. If cause-effects relationship and quantification can be required, for example, in formulating national or international economic and political decisions, predicting the consequences. In other cases, as it could be at local level, for governance purposes or entrepreneurial management decision-making processes, an interpretivist stance would be prefereable, in favour of dialogue, consensus and stakeholders participation.

What remains to be discussed in SLCA academia, is about the awareness that the paradigmatic stance matters when social impacts are assessed. The present study wants to be a contribution to this.

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Appendix

Tab. A.1 Criteria for the critical review of sLCA literature

Criteria (examples)
Typology of indicators applied/proposed
Typology of impact assessment method
Main purpose of the assessment
Conception of social impacts
Theory underlying the assessment
Typology of data gathering process
Statistical validity
Importance given to dialogue and consensus
Participative processes
Quantification method
Importance of context
Generalizability of results

Tab. A.2 Critical review results

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
1	Albrecht S, Brandstetter P, Beck T, Fullana-i-Palmer P, Grönman K, Baitz M, Deimling S, Sandilands J, Fischer M	2013	An extended life cycle analysis of packaging systems for fruit and vegetable transport in Europe	Int J LCA 18(8):1549-1567	JA	Packaging	LCA + LCC + Life Cycle Working Environment	GaBi software and database	i
2	Andrews E, Lesage P, Benoît C, Parent J, Norris G, Revéret JP	2009	Life Cycle Attribute Assessment. Case Study of Quebec Greenhouse Tomatoes	Journal of Industrial Ecology 13(4):565-578	JA	Greenhouse tomatoes	Life Cycle Attribute Assessment	Attribute LCA; labour hour satellite matrix	i
3	Aparcana S, Salhofer S	2013a	Development of a social impact assessment methodology for recycling systems in low-income countries.	Int J LCA 18(5):1106-1115	JA	Waste: recycling systems	SLCA	UNEP-SETAC guidelines + interviews + score system	i
4	Aparcana S, Salhofer S	2013b	Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies	Int J LCA 18(5):1116-1128	JA	Waste: recycling systems	SLCA	UNEP-SETAC guidelines + stakeholders interview + score system	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
5	Arcese G, Di Pietro L, Guglielmetti Mugion R	2015	Social Life Cycle Assessment Application: Stakeholder Implication in the Cultural Heritage Sector	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 115-146	BC	Cultural heritage sector	SLCA	UNEP-SETAC guidelines, SAM + consistency scoring	i
6	Arcese G, Lucchetti MC, Martucci O	2015	Social Life Cycle Assessment in a Managerial Perspective: An Integrative Approach for Business Strategy	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 227-252	BC	Business management	SLCA	UNEP-SETAC guidelines	i
7	Arcese G, Lucchetti MC, Merli R	2013	Social Life Cycle Assessment as a Management Tool: Methodology for Application in Tourism	Sustainability 5:3275-3287	JA	Tourism services	SLCA	UNEP-SETAC guidelines	i
8	Arvidsson R, Baumann H, Hildenbrand J	2015	On the scientific justification of the use of working hours, child labour and property rights in social life cycle assessment: three topical reviews	Int J LCA 20(2):161-173	JA	SLCA development	SLCA	Pathway	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
9	Baumann H, Arvidsson R, Tong H, Wang Y	2013	Does the Production of an Airbag Injure more People than the Airbag Saves in Traffic? Opting for an Empirically Based Approach to Social Life Cycle Assessment	Journal of Industrial Ecology 17(4):517-527	JA	Airbags	SLCA	Disability-adjusted life years (DALY)	pp
10	Benoît C, Norris GA, Valdivia S, Ciroth A, Moberg A, Bos U, Prakash S, Ugaya C, Beck T	2010	The guidelines for social life cycle assessment of products: just in time!	Int J LCA 15(2):156-163	JA	SLCA development	SLCA	UNEP-SETAC guidelines	i
11	Benoît Norris C	2012	Social Life Cycle Assessment: A Technique Providing a New Wealth of Information to Inform Sustainability-Related Decision Making	In: Curran M.A. (Ed), Life Cycle Assessment Handbook, Wiley, pp.433-450.	BC	SLCA development	SLCA	UNEP-SETAC guidelines	i
12	Benoît Norris C	2014	Data for social LCA	Int J LCA 19(2):261-265	JA	SLCA development	SLCA	UNEP-SETAC guidelines	i
13	Benoît Norris C, Aulisio D, Norris GA, Hallisey-Kepka C, Overakker S, Vickery Niederman G	2011	A social Hotspot Database for Acquiring Greater Visibility in Product Supply Chains: Overview and Application to Orange Juice	In: Finkbeiner M (ed) Towards Life Cycle Sustainability Management, pp. 53-62, Springer	BC	Orange juice	SLCA	SHDB	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
14	Benoît Norris C, Aulisio Cavan D, Norris GA	2012a	Identifying Social Impacts in Product Supply Chains: Overview and Application of the Social Hotspot Database	Sustainability 4(9):1946-1965	JA	Strawberry yogurt	SLCA	Social Hotspot Database	i
15	Benoît Norris C, Aulisio Cavan D, Norris GA	2012b	Working with the Social Hotspots Database - Methodology and Findings from 7 Social Scoping Assessments	In: Dornfeld DA, Linke BS (Eds) Leveraging Technology for a Sustainable World. Proceedings of the 19th CIRP Conference on Life Cycle Engineering, Berkeley, USA, May 23-25 (pp. 581-586). Springer.	CP	Shampoo supply chain	SLCA	Social Hotspot Database	i
16	Benoît Norris C, Norris GA, Aulisio D	2014	Efficient Assessment of Social Hotspots in the Supply Chains of 100 Product Categories Using the Social Hotspots Database	Sustainability 6(10):6973-6984	JA	100 product categories	SLCA	Social Hotspot Database	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
17	Benoît Norris C, Revéret JP	2015	Partial Organization and Social LCA Development: The Creation and Expansion of an Epistemic Community	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 199-226	BC	SLCA development	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i
18	Benoît Norris C, Vickery-Niederman G, Valdivia S, Franze J, Traverso M, Ciroth A, Mazijn B	2011	Introducing the UNEP/SETAC methodological sheets for subcategories of social LCA	Int J LCA 16(7):682-690	JA	SLCA development	SLCA	UNEP-SETAC guidelines	i
19	Bocoum I, Macombe C, Revéret JP	2015	Anticipating impacts on health based on changes in income inequality caused by life cycles	Int J LCA 20(3):405-417	JA	Income inequality and health	SLCA	Wilkinson Pathway	pp
20	Bork CAS, Junior DJDB, Gomez JDO	2015	Social Life Cycle Assessment of three Companies of the furniture sector.	Procedia CIRP 29: 150-155	CP	Furniture for buildings construction	SLCA	UNEP-SETAC guidelines	i
21	Bouzid A, Padilla M	2014	Analysis of social performance of the industrial tomatoes food chain in Algeria	NEW MEDIT N. 1/2014, pp. 60-65	JA	Tomatoes	SLCA	UNEP-SETAC guidelines	i
22	Chang Y-J, Sproesser G, Neugebauer S, Wolf K, Scheumann R, Pittner A, Rethmeier M, Finkbeiner M	2015	Environmental and Social Life Cycle Assessment of Welding Technologies	Procedia CIRP 26:293-298	CP	Welding technology	LCA + SLCA	Fair salary and health risks	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
23	De Luca AI, Iofrida N, Strano A, Falcone G, Gulisano G	2015b	Social Life Cycle Assessment and participatory approaches: a methodological proposal applied to citrus farming in Southern Italy	Int Env Assesst and Manag 11(3):383396	JA	Clementine	SLCA	UNEP-SETAC guidelines + participatory approach	i
24	Dong YH, Ng ST	2015	A social life cycle assessment model for building construction in Hong Kong	Int J LCA 20(8):1166-1180	JA	Buildings	SLCA	UNEP-SETAC guidelines	i
25	Dreyer LC, Hauschild MZ, Schierbeck J	2006	A Framework for Social Life Cycle Impact Assessment	Int J LCA 11(2):88-97	JA	SLCA development	SLCA	Scorecard multicriteria indicator model	i
26	Dreyer LC, Hauschild MZ, Schierbeck J	2010a	Characterisation of social impacts in LCA Part 1: Development of indicators for labour rights	Int J LCA 15(3):247-259	JA	SLCA development	SLCA	social risk assessment	i
27	Dreyer LC, Hauschild MZ, Schierbeck J	2010b	Characterisation of social impacts in LCA. Part 2: implementation in six company case studies	Int J LCA 15(4):385-402	JA	Industry	SLCA	social risk assessment	i
28	Ekener-Petersen E, Finnveden G	2013	Potential hotspots identified by social LCA—part 1: a case study of a laptop computer	Int J LCA 18(1):127-143	JA	Laptop computer	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
29	Ekener-Petersen E, Höglund J, Finnveden G	2014	Screening potential social impacts of fossil fuels and biofuels for vehicles	Energy Policy 73:416-426	JA	Fossil and biological fuels	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i
30	Ekener-Petersen E, Moberg Å	2013	Potential hotspots identified by social LCA-Part 2: Reflections on a study of a complex product	Int J LCA 18(1):144-154	JA	Laptop computer	SLCA	UNEP-SETAC guidelines, Social Hotspot Database	i
31	Feschet P, Macombe C, Garrabé M, Loeillet D, Rolo Saez A, Benhmad F	2013	Social impact assessment in LCA using the Preston pathway. The case of banana industry in Cameroon	Int J LCA 18(2):490-503	JA	Bananas	SLCA	Preston Pathway	pp
32	Foolmaun RK, Ramjeeawon T	2013a	Life cycle sustainability assessments (LCSA) of four disposal scenarios for used polyethylene terephthalate (PET) bottles in Mauritius	Environment, Development and Sustainability 15(3):783-806	JA	Waste	LCSA	UNEP-SETAC guidelines	i
33	Foolmaun RK, Ramjeeawon T	2013b	Comparative life cycle assessment and social life cycle assessment of used polyethylene terephthalate (PET) bottles in Mauritius	Int J LCA 18(1):155-171	JA	Waste	LCA + SLCA	UNEP-SETAC guidelines	i
34	Franze J, Ciroth A	2011	A comparison of cut roses from Ecuador and the Netherlands	Int J LCA 16(4):366-379	JA	Roses	SLCA	UNEP-SETAC guidelines	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
35	Gauthier C	2005	Measuring Corporate Social and Environmental Performance: The Extended Life-Cycle Assessment	Journal of Business Ethics 59(1): 199-206	JA	Business strategy and management	"Extended" LCA	Systematic assessment of social criteria in extended LCA	i
36	Hauschild MZ, Dreyer LC, Jørgensen A	2008	Assessing social impacts in a life cycle perspective - Lessons learned	CIRP Annals - Manufacturing Technology 57(1):21-24	JA	SLCA development	SLCA	Companies behavior	i
37	Heller MC, Keoleian GA	2003	Assessing the sustainability of the US food system: a life cycle perspective	Agricultural Systems 76(3):1007-1041	JA	Food systems	LCSA	Attibutive assessment through static indicators	i
38	Hosseinijou SA, Mansour S, Shirazi MA	2014	Social life cycle assessment for material selection: a case study of building materials	Int J LCA 19(3):620-645	JA	Building materials	SLCA	UNEP-SETAC guidelines	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
39	Hsu C-W, Wang S-W, Hu A	2013	Development of a New Methodology for Impact Assessment of SLCA	In: Nee AYC, Song B, Ong S-K, (Eds) Re-engineering Manufacturing for Sustainability. Proceedings of the 20th CIRP International Conference on Life Cycle Engineering, Singapore 17-19 April, 2013. pp. 469-473	CP	SLCA development	SLCA	UNEP-SETAC guidelines and Performance Reference points	i
40	Hu M, Kleijn R, Bozhilova-Kisheva KP, Di Maio F	2013	An approach to LCSA: the case of concrete recycling	Int J LCA 18(9):1793-1803	JA	Recycling	LCSA	UNEP-SETAC guidelines	i
41	Hunkeler D	2006	Societal LCA methodology and case study.	Int J LCA 11(6):371-382	JA	Detergents	SLCA	Geographically specific midpoint based	pp
42	Jørgensen A	2013	Social LCA - a way ahead?	Int J LCA 18(2):296-299	JA	SLCA development	SLCA	Pathway	pp
43	Jørgensen A, Finkbeiner M, Jørgensen MS, Hauschild MZ	2010	Defining the baseline in social life cycle assessment	Int J LCA 15(4):376-384	JA	SLCA development	SLCA	Pathway	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
44	Jørgensen A, Hauschild MZ, Jørgensen MS, Wangel A	2009	Relevance and feasibility of social life cycle assessment from a company perspective	Int J LCA 14(3):204-214	JA	Company	SLCA	interviews	i
45	Jørgensen A, Lai LC, Hauschild MZ	2010	Assessing the validity of impact pathways for child labour and well-being in social life cycle assessment	Int J LCA 15(1):5-16	JA	Child labour	SLCA	Pathway	pp
46	Kruse SA, Flysjö A, Kasperczyk N, Scholz AJ	2009	Socioeconomic indicators as a complement to life cycle assessment—an application to salmon production systems.	Int J LCA 14(1):8-18	JA	Salmon	Socio-economic LCA	Attributive and descriptive assessment	i
47	Lagarde V, Macombe C	2012	Designing the social life cycle of products from the systematic competitive model	Int J LCA 18(1):172-184	JA	System boundaries definition	SLCA	Systematic Competitive Model	pp
48	Lehmann A, Russi D, Bala A, Finkbeiner M, Fullana-i-Palmer P	2011	Integration of Social Aspects in Decision Support, Based on Life Cycle Thinking	Sustainability 3(4):562-577	JA	Water management and packaging waste	SLCA	UNEP-SETAC guidelines + literature	i
49	Lehmann A, Zschieschang E, Traverso M, Finkbeiner M, Schebek	2013	Social aspects for sustainability assessment of technologies - challenges for social life cycle assessment (SLCA)	Int J LCA 18(8):1581-1592	JA	Technologies	SLCA	UNEP-SETAC guidelines	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
50	Macombe C, Leskinen P, Feschet P, Antikainen R	2013	Social life cycle assessment of biodiesel production at three levels: a literature review and development needs	Journal of Cleaner Production 52(1):205-216	JA	Energy	SLCA	Pathway	pp
51	Manik Y, Leahy J, Halog A	2013	Social life cycle assessment of palm oil biodiesel: a case study in Jambi Province of Indonesia	Int J LCA 18(7):1386-1392	JA	Energy	SLCA	UNEP-SETAC guidelines	i
52	Martínez-Blanco J, Lehman A, Munoz P, Antòn A, Traverso M, Rieradevall J, Finkbeiner M	2014	Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment	Journal of Cleaner Production 69 34-48	JA	Fertilizers	LCSA	UNEP-SETAC guidelines	i
53	Mathé S	2014	Integrating participatory approaches into social life cycle assessment: the SLCA participatory approach	Int J LCA 19(8):1506-1514	JA	Fisheries	Participatory SLCA	Participatory approach	i
54	Musaazi MK, Mechtenberg AR, Nakibuule J, Sensenig R, Miyingo E, Makanda JV, Hakimian A, Eckelman MJ	2015	Quantification of social equity in life cycle assessment for increased sustainable production of sanitary products in Uganda	Journal of Cleaner Production 96 569-579	JA	Sanitary pads	LCA + SLCA	Pathway	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
55	Nemarumane TM, Mbohwa C	2015	Social Life Cycle Assessment in the South African Sugar Industry: Issues and Views	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 71-113	BC	Sugar cane	SLCA	UNEP-SETAC guidelines	i
56	Neugebauer S, Martinez-Blanco J, Scheumann R, Finkbeiner M	2015	Enhancing the practical implementation of life cycle sustainability assessment. Proposal of a Tiered approach	Journal of Cleaner Production 102:165-176	JA	SLCA development	LCSA	UNEP-SETAC guidelines + Tiered approach	i
57	Neugebauer S, Traverso M, Scheumann R, Chang Y-J, Wolf K, Finkbeiner M	2014	Impact Pathways to Address Social Well-Being and Social Justice in SLCA-Fair Wage and Level of Education	Sustainability 6(8):4839-4857	JA	SLCA development	SLCA	Pathway	pp
58	Norris GA	2006	Social Impacts in Product Life Cycles - Towards Life Cycle Attribute Assessment.	Int J LCA 11: 97-104	JA	SLCA development	SLCA	Pathway + Life Cycle Attribute Assessment	pp + i
59	Ramirez SPK, Petti L, Haberland NT, Ugaya CML	2014	Subcategory assessment method for social life cycle assessment. Part 1: methodological framework	Int J LCA 19(8):1515-1523	JA	SLCA development	SLCA	SAM	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
60	Ramirez SPK, Petti L, Ugaya CML	2014	Subcategory assessment method for social LCA: A first application on the wine sector	In: Salomone R, Saija G (eds):Pathways to environmental sustainability: Methodologies and experiences. Springer	BC	Wine	SLCA	SAM	i
61	Reitinger C, Dumke M, Barosevcic M, Hillerbrand R	2011	A conceptual framework for impact assessment within SLCA	Int J LCA 16(4):380-388	JA	SLCA development	SLCA	Capabilities approach	i
62	Revéret JP, Couture JM, Parent J	2015	Socioeconomic LCA of Milk Production in Canada	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 25-69	BC	Milk	SLCA	UNEP-SETAC guidelines + SHDB	i
63	Rugani B., Benedetto E, Igos E, Quinti G, Declich A, Feudo F	2014	Towards prospective life cycle sustainability analysis: exploring complementarities between social and environmental life cycle assessments for the case of Luxembourg's energy system	Materiaux & Techniques 102, 605 (2014)	JA	Energy	LCA + SLCA	SHDB	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
64	Sandin G, Peters G, Pilgård A, Svanström M, Westin M	2011	Integrating Sustainability Considerations into Product Development: A Practical Tool for Prioritising Social Sustainability Indicators and Experiences from Real Case Application	In: Finkbeiner M (ed) Towards Life Cycle Sustainability Management, pp. 3-14, Springer	BC	SLCA development	SLCA	UNEP-SETAC guidelines	i
65	Santoyo-Castelazo E, Azapagic A	2014	Sustainability assessment of energy systems: integrating environmental, economic and social aspects	Journal of Cleaner Production 80:119-138	JA	Energy	Sustainability assessment	Social interpretation LCA indicators	i
66	Schmidt I, Meurer M, Saling P, Reuter W, Kicherer A, Gensch C-O	2004	Managing Sustainability of Products and Processes with the Socio-Eco-Efficiency Analysis by BASF	Greener Management International 45:79-94	JA	Energy	Socio-eco-efficiency	SEEBalance	i
67	Smith J, Barling D	2014	Social impacts and life cycle assessment: proposals for methodological development for SMEs in the European food and drink sector	Int J LCA 19(4):944-949	JA	Food and drink	SLCA	Qualitative bottom-up and top down approach	i
68	Traverso M, Asdrubali F, Francia A, Finkbeiner M	2012	Towards Life Cycle Sustainability assessment: an implementation to photovoltaic modules	Int J LCA 17(8):1068-1079	JA	Energy	LCSA	UNEP-SETAC guidelines + LCSA dashboard	i

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
69	Traverso M, Finkbeiner M	2012	Life Cycle Sustainability Dashboard	Journal of Industrial Ecology 16(5):680-688	JA	Natural hard floor coverings	LCSA	UNEP-SETAC guidelines	i
70	Umair S, Björklund A, Ekener-Petersen E	2015	Social Life Cycle Inventory and Impact Assessment of Informal Recycling of Electronic ICT Waste in Pakistan	Resources, Conservation and Recycling 95 46-57	JA	Waste	SLCA	UNEP-SETAC guidelines	i
71	Valdivia S, Ugaya CML, Hildenbrand J, Traverso M, Mazijn B, Sonnemann G	2013	A UNEP/SETAC approach towards a life cycle sustainability assessment - our contribution to Rio+20	Int J LCA 18(9):1673-1685	JA	Marble	LCSA	UNEP-SETAC guidelines	i
72	Vavra J, Munzarova S, Bednarikova M	2015	Assessment of Social Impacts of Chemical and Food Products in the Czech Republic	In: Muthu SS (eds), Social Life Cycle Assessment, Springer Singapore, pp 147-197	BC	Chemical and food products	SLCA	UNEP-SETAC guidelines and qualitative weighting	i
73	Vinyes E, Oliver-Solà J, Ugaya C, Rieradevall J, Gasol CM	2013	Application of LCSA to used cooking oil waste management.	Int J LCA 18(2):445-455.	JA	Waste	LCSA	general indicators	i
74	Weidema BP	2005	ISO 14044 also Applies to Social LCA	Int J LCA 10(6):381-381	JA	SLCA development	SLCA	Two-layer SLCA method	pp

N.	Author	Year	Title	Source	Literature typology	Field of application or study	Methodologies	Impact Assessment methodology (applied or proposed)	Paradigms family
75	Weidema BP	2006	The integration of Economic and Social Aspects in Life Cycle Impact Assessment	Int J LCA 11:89-96	JA	SLCA development	SLCA	Pathway	pp
76	Weldegiorgis FS, Franks DM	2014	Social dimensions of energy supply alternatives in steelmaking: comparison of biomass and coal production scenarios in Australia	Journal of Cleaner Production 84:281-288	JA	Energy	SLCA	UNEP-SETAC guidelines	i
77	Wilhelm M, Hutchins, Mars C, Benoit Norris C	2015	An overview of social impacts and their corresponding improvement implications: a mobile phone case study	Journal of Cleaner Production 102:302-315	JA	Mobile phones	SLCA	SHDB	i
78	Wu SR, Chen J, Apul D, Fan P, Yan Y, Fan Y, Zhou P	2015	Causality in social life cycle impact assessment (SLCIA)	Int J LCA 20(9):1312-1323	JA	SLCA development	SLCA	Pathway	pp

Legend: JA (Journal Article); CP (Conference Proceedings); BC (Book Chapter); pp (post-positivism); i (interpretivism).

Tab. A.3 PRF Matrix

Risk Factors (working conditions)	Hearing damages	Cardiovascular disease	Gastric cancer	Suicide thoughts	Metabolic syndrome	MSDs				Lower self esteem	Psychological distress	High level of stress perceived	Disability	Osteoarthritis	Chronic bronchitis
						Sciatic Pain	Back Pain	Neck and Shoulders	Upper Limbs						
Noise									1,58 (Stock *et al.* 2006)						
Total Boby Vibrations (tractor driving)						3,9 (Bovenzi and Betta)	1,83 (Bovenzi and Betta, 1994)	2,07 (Stock *et al.* 2006)							
Vibration manual tools(chain saw)									2,44 (Stock *et al.* 2006)						
High physical demand							4,4 (Raeisi *et al.* 2014)	2,1 (Stock *et al.* 2006)	1,66 men (Stock *et al.*)				2,02 (Lahelma, 2012)		
Temporary employment							2,00 (Domenighetti *et al.* 1999)			2,9 (Domenighetti *et al.* 1999)		1,6 (Domenighetti *et al.* 1999)			
Outdoor working environment															1,77 (Kotaniemi *et al.* 2003)
Heavy manual labour														2,8 in agriculture (Rossignol *et al.* 2005)	
Citrus chemicals exposure	1,19 (Crawford *et al.* 2008)		2,88 (Mills and Yang 2007)												
Long working hours >8 to 9 hours/ day				1,38 (Yoon *et al.* 2015)	1,66 (Kobayashi *et al.* 2012)										
Long working hours >9 to 10 hours/day				2,01 (Yoon *et al.* 2015)	1,48; (Kobayashi *et al,* 2012)										

Risk Factors (working conditions)	Hearing damages	Cardiovascular disease	Gastric cancer	Suicide thoughts	Metabolic syndrome	MSDs				Lower self esteem	Psychological distress	High level of stress perceived	Disability	Osteoarthritis	Chronic bronchitis
						Sciatic Pain	Back Pain	Neck and Shoulders	Upper Limbs						
Long working hours >10 hours/day				2,01 (Yoon *et al.* 2015)	(Kobayashi *et al.* 2012)										
Work pressure		3,45 (Siegrist 1996)													
Effort-reward imbalance		6,15 (Siegrist 1996)													
High psychological demand											2,04 (Bourbonnais, 1996)				

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