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Review Article

Exploring the Advantages and Disadvantages in Social Life Cycle Assessment: A Critical Review of Assessment Methods

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ABSTRACT

Social life cycle assessment is considered a useful method where the social impact of a product or service is assessed. Not only environmental and economic, but also social impact and sustainability are mentioned more and more often. Therefore, the increasing popularity of the social life cycle encourages the study of the existing situation in the scientific literature. Not only environmental and economic, but also social impact and sustainability are mentioned more and more often. Therefore, the increasing popularity of the social life cycle encourages the study of the existing situation in the scientific literature. The aim of this research is to conduct a bibliometric analysis to assess the status and trends, conduct a literature review and advantage and disadvantages analysis and to define criteria for choosing the appropriate social life cycle method. The method used is bibliometric analysis to assess quantitatively and literature analysis to assess qualitative methods. Social life cycle analysis popularity is increasing, and main increase in number of publications was in 2020-2021. In the literature review and advantage and disadvantages analysis were analysed the United Nations Environment Programme guidelines and the Social Hotspots Database and Product Social Impact Life Cycle Assessment databases and as main advantages was a wide range of indicators, but the biggest disadvantage is that the databases require a program and licenses. Quantitative and qualitative assessment of social life cycle is the result, and criteria that help to choose the most suitable method are one of the results. Social impact assessment is gaining popularity as importance of considering all three dimensions of sustainability - environmental, economic, and social.

KEYWORDS

Social life cycle assessment, Review, Advantage and disadvantages analysis, Social Hotspots Database, Product Social Impact Life Cycle Assessment, United Nations Environment Programme guidelines.

INTRODUCTION

Social sustainability focuses on people and is part of sustainability pillars [1]. The importance of social sustainability is also demonstrated by the Sustainable Development Goals of the United Nations, and all of the 17 goals address social problems [2]. As one of the main goals of society's development is social well-being - understanding what improves or worsens well-being and its evaluation is a necessary element for growth [3]. Social impact can be both

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positive and negative pressure on social parameters or the well-being of stakeholders [4]. The well-being of the individual and the community is promoted through social benefits [5].

Social life cycle assessment (S-LCA) is considered a useful method where the social impact of a product or service is assessed [6]. S-LCA is based on the environmental life cycle assessment (LCA) ISO 14040 framework and consist of four phases – goal and scope, inventory, impact assessment and interpretation [1]. Goal and scope define the purpose of the activity and its boundaries of assessment [7]. In the inventory phase, data on the evaluated product/service are collected by categories, subcategories, and indicators [7]. The impact assessment phase is where the appropriate assessment method is chosen, and therefore the type of results that will be obtained and their interpretation [7].

In the 1990s, discussions began on integrating social aspects into LCA [8]. Social life cycle assessment is currently well developed, but it takes time to reach scientific maturity, as four stages of development are distinguished - the early days of social life cycle assessment (1996–2009), the years of uncertainty (2009–2012), the years of development (2013– 2016) and the search for standardization (2017–present) [9]. S-LCA has become more popular in recent years as a method to assess the positive and negative social impacts of a product's life cycle, from raw material extraction to final disposal, or from cradle to grave [10].

Social impact assessment is becoming increasingly important as interest in the impact of an action or decision on society and the environment grows, and social impact is a dynamic process that needs to be independently assessed [11]. S-LCA is used in various sectors, for example textile production was assessed according to United Nations Environment Programme (UNEP) guidelines with the aim of carrying out a social value assessment of the product and it was concluded that the local processes of textile production in Italy respect the needs of people and local communities [12]. The S-LCA study on the use of LED luminaires used the Product Social Impact Life Cycle Assessment (PSILCA) database to address the main social risks and defined four social problems - association and bargaining rights, sanitation coverage, public sector corruption" and pollution [13]. Using the Social Hotspots Database (SHDB) database, an S-LCA assessment was carried out to define the social hot spots of sugarcane production in Brazil and it is concluded that the major risks are health and safety, labour rights and decent work [14].

The aim of this research is to conduct a bibliometric analysis to assess the status and trends of S-LCA. Conduct a literature review and advantage and disadvantages analysis on S-LCA methods to define criteria for choosing the appropriate S-LCA method.

METHODS

This research consists of two main steps (**Figure 1**) to achieve S-LCA method assessment and guidelines on how to choose the most suitable method. Bibliometric analysis is used to clarify the current S-LCA situation - dynamics of publications, keywords used in publications and research areas. Literature review, advantage and disadvantages analysis shows characteristics of S-LCA methods and then the criteria are defined for selecting the most appropriate S-LCA method.

Bibliometric analysis can be used to analyze large amounts of scientific data and is a very popular method to use [15]. Results from bibliometric analysis show industry trends and changes over the years. Scope of this bibliometric analysis is S-LCA popularity in publication over the years. Defining a keyword in the Web of Science database by title, abstract, and author keywords are research boundaries. This research is based on co-word analysis because it shows connection between words that appear in publications and forms clusters. The result of the bibliometric analysis is a keyword co-occurrence network and the VOSviewer software is used for this type of visualization.

Scope of literature review, advantage and disadvantages analysis and for defining the criteria is S-LCA database tow methods (SHDB and PSILCA) and UNEP methodology as

social assessment tools. From literature review part is formed advantages and disadvantages analysis, then an interpretation criteria for choosing the S-LCA method.

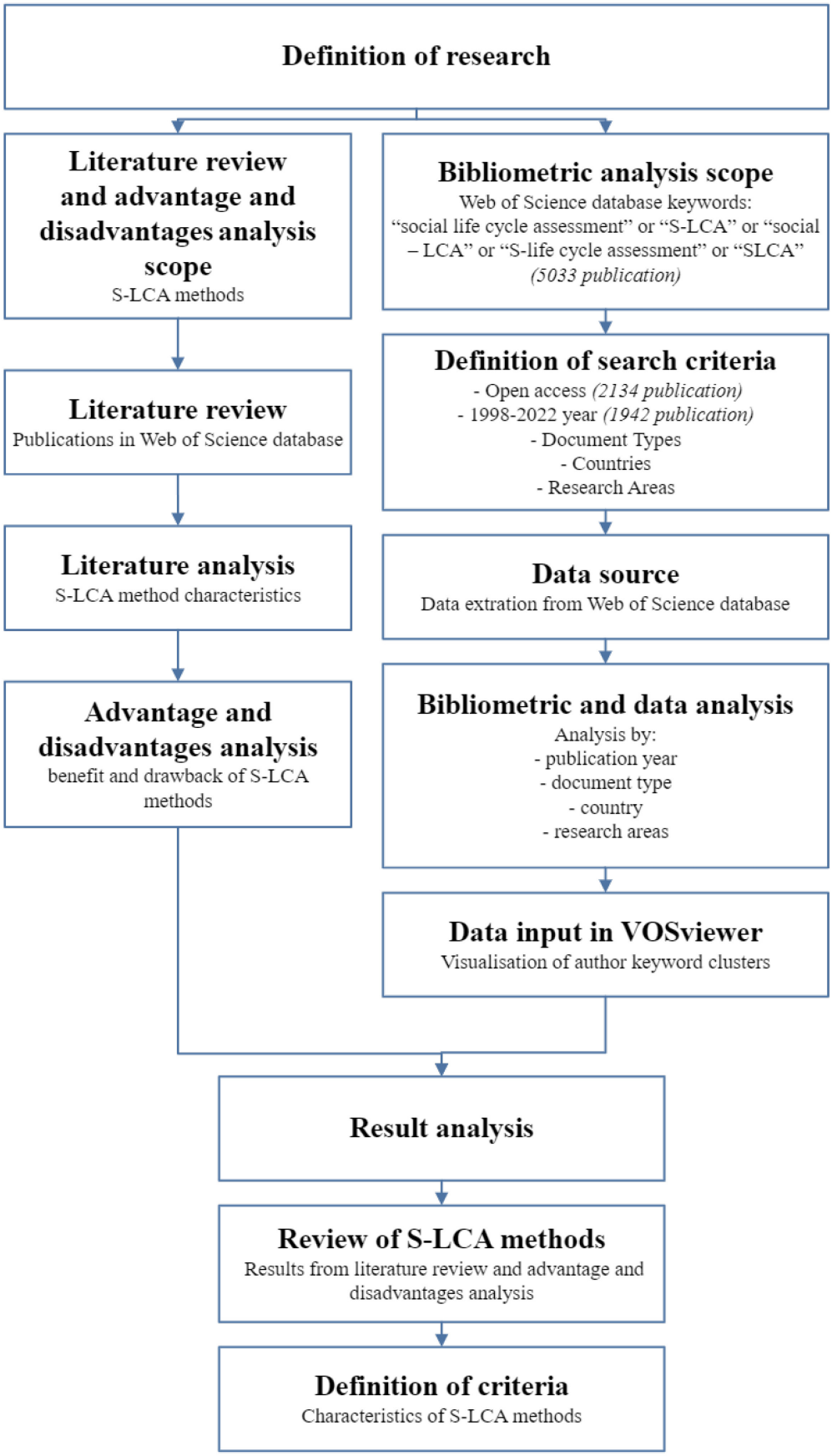

Figure 1. Methodology used in the research

RESULTS AND DISCUSSION

There is a trend that the number of scientific papers on S-LCA is increasing, and it is a very popular topic for European authors. Also, S-LCA assessment methods are evolving and improving over time, although each method has its advantages and disadvantages, but in general methods should be chosen according to the type of data available, whether there is a desire to compare results, and whether there is an available library and database for the software.

Bibliometric analysis

Bibliometric analysis was obtained in the title, abstract and author keywords by using keywords "social life cycle assessment" or "S-LCA" or "social – LCA" or "S-life cycle assessment" or "SLCA". From 1998 to 2022, the number of open access publications by keywords is 1942, see **Figure 2**. The number of publications has increased more rapidly in the periods 2020-2021 and 2018-2019.

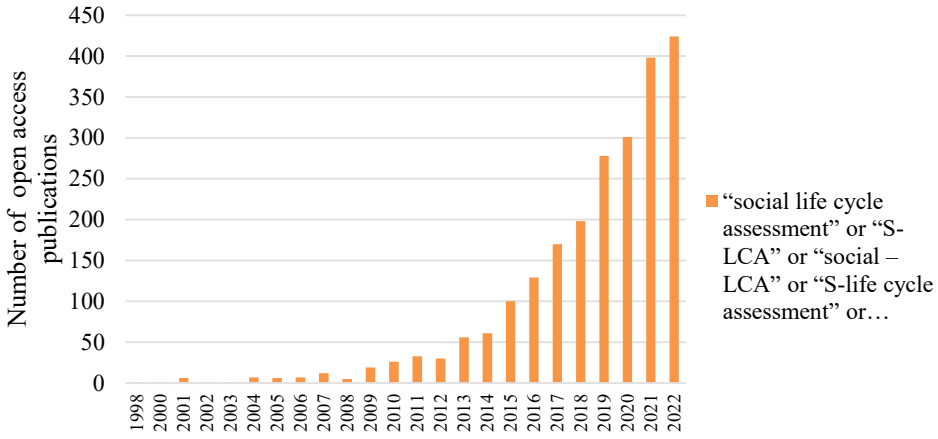

Figure 2 Number of open access publications in 1998-2022

Results of the biometric analysis shows that S-LCA is growing in popularity and life cycle is not only assessed from environmental and economic aspects, but also on social aspects as well. In December 2023, the first Social Product Declaration was published, showing social sustainability in a life cycle perspective and it took 25 years for the EPD International platform to see any innovation in life cycle assessment **[16]**. It is very likely that this event will move the industry and more and more companies and industries will focus on a more serious assessment of social aspects.

Figure 3 shows results about publications document type and 76% is as articles, 14% is as review articles and 9% is as proceeding papers. Other document types such as editorial material, early access, data paper, book, correction, letter, retracted publication makes up less than 1%.

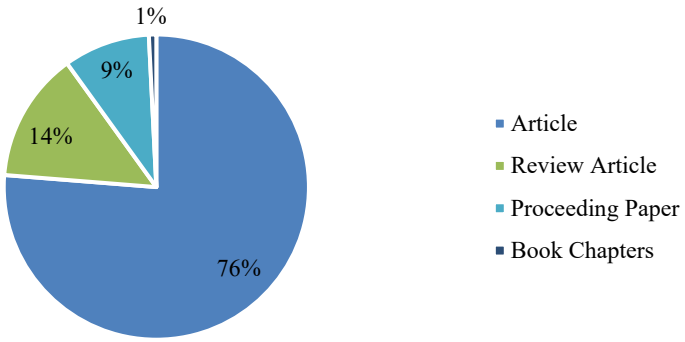

Figure 3. Publications document type

Most of the research results are in the form of original research articles and then review articles follow, thus the field of social evaluation in science develops with new and original research and discoveries, as well as synthesizing and analysing existing articles, creating new knowledge and contributing to the development of the field.

Table 1 shows the top 15 countries that publish publications on the social life cycle. As leader is The USA (425 publication), followed by United Kingdom (352 publication), Spain (248 publication), Germany (241 publications) and Italy (227 publications). 10 of the 15 countries are European and these 10 countries together have twice as many publications as the other 5 countries combined. This means that social life cycle assessment is popular in Europe. **Table 1** shows the annual articles published in science and technology journals per million people in 2018 for these top 15 countries. Denmark, Australia, Sweden, the Netherlands and Canada have the most articles published per million people and out of these 5 countries, three European countries together account for two thirds of the articles.

Table 1. Publications are refined by country

Country	Number of publications	Articles per million people in 2018 [17]
USA	425	1273
United Kingdom	352	1470
Spain	248	1166
Germany	241	1259
Italy	227	1190
People's Republic of China	169	373
Netherlands	132	1762
France	114	1032
Australia	111	2146
Sweden	110	2009
Canada	99	1619
Brazil	74	286
Denmark	69	2424
Belgium	65	1370
Poland	65	926

The results in **Table 1** show that social life cycle assessment is popular in Europe and that various types of studies are being developed in this field. Although the population in European countries is not large, the number of publications shows the willingness of experts to undertake and publish research and European countries have made significant contributions to the field of social aspects.

As most popular research area for selected keywords is environmental sciences ecology, science technology other topics and engineering. **Table 2** shows the top 15 research areas from publications that matched the defined keywords.

The number of publications in these research fields shows the interest in social aspects and researchers are integrating the different fields to analyse and possibly improve sustainability not only from an environmental point of view but also from a social point of view. Different disciplines are being brought together to address problems in a more effective and multifaceted way.

Table 2. Publications are refined by research areas

Research Areas	Number of publications
Environmental sciences ecology	1047
Science technology other topics	793
Engineering	690
Energy fuels	232
Construction building technology	106
Business economics	86
Materials science	62
Psychology	58
Agriculture	54
Psychiatry	53
Computer science	52
Chemistry	43
Health Care Sciences Services	36
General Internal Medicine	33
Physics	31

The results from VOSviewer are in **Figure 4**, with the author's keyword occurrence of 10, and it is divided into 7 clusters. The Life Cycle Assessment cluster is the largest with 322 and 73 links, followed by the Sustainability cluster with 299 and 81 links, and the average publication year of both clusters is the first half of 2018. After that, the Circular Economy cluster with 106 and 46 links has an average publication year of 2020, followed by the Social Life Cycle Assessment cluster with 81 and 38 links with an average publication year of 2019.

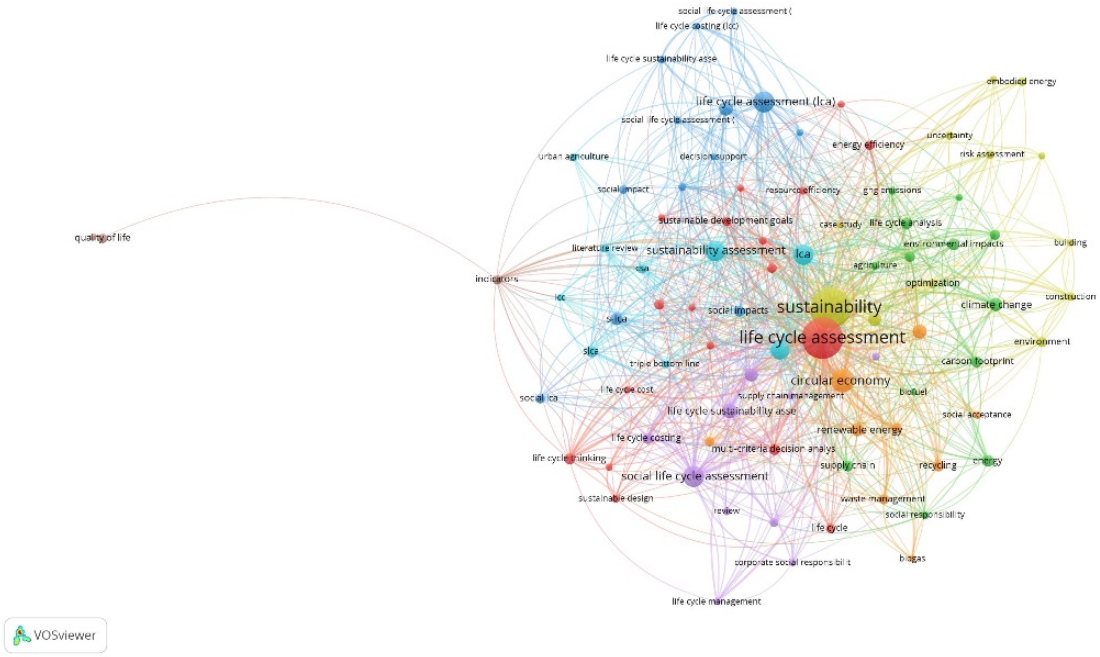

Figure 4. Author keyword co-occurrence network

The life cycle cluster is the largest and has the highest number of links, showing what is relevant to other clusters, although the S-LCA cluster is small, there are links to other clusters showing the interest in social aspects from other sectors. Diverse range of clusters shows what the relationship between links are and in different sectors.

Literature review, advantage and disadvantages analysis

Different types of methods can be used for S-LCA assessment and thus different types of results are obtained. In **Figure 5** are few main assessment methods for S-LCA, but each method has a different approach and result. Of all the methods, the database methods as SHPD and PSILCA and the evaluation methods as UNEP guidelines will be discussed and analysed further. In the database methods, the values of the impact categories are obtained, while the impact of another method is evaluated by the reference value or by ranking. S-LCA has two main approaches [18]:

- a reference scale (RS) approach that focuses on behaviour/achievement across the life cycle;
- an impact pathways (IP) approach that focuses on the ultimate social impact on people of activities across the life cycle.

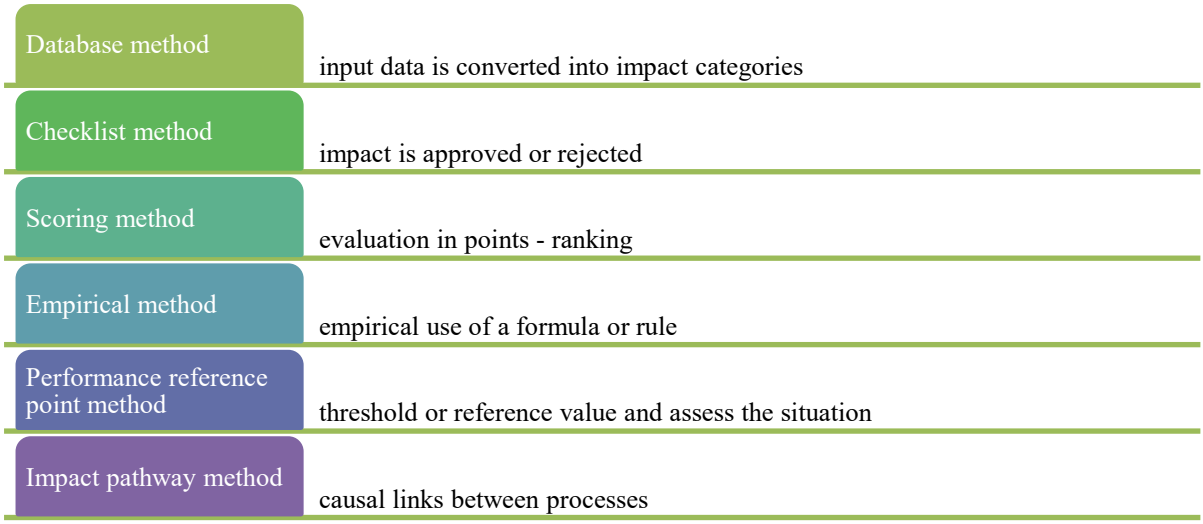

Figure 5. S-LCA assessment methods [19]

The S-LCA standardisation consists of several databases, e.g. the SHDB, the PSILCA database, while for specific social assessments the UNEP methodology is available as a standardised tool [9]. **Figure 6** shows some important years in the development and implementation of the S-LCA methodology for the SHDB, the PSILCA database and UNEP methodology.

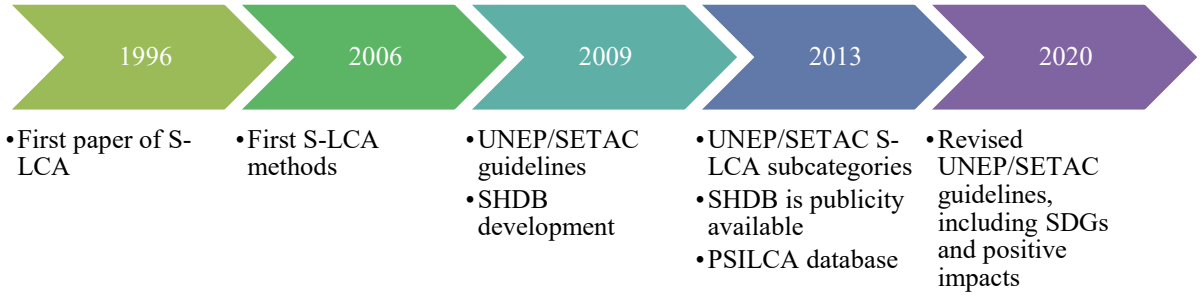

Figure 6. Development of S-LCA and methods [20]

The UNEP guidelines, the SHDB and the PSILCA database are constantly being refined and improved. The UNEP 2021 guidelines, a sixth category of stakeholders has arrived - children, since there were five categories of stakeholders in the 2009 UNEP guidelines [21]. As SHDB and PSILCA are two major databases used for S-LCA [19]. Also, UNEP guidelines

are a popular method to use for S-LCA assessment, in **Table 3** is comparison of UNEP guidelines, SHDB database and PSILCA database key features.

Table 3. Comparison of key features of S-LCA assessment methods [1], [20], [23], [24], [25], [26], [28], [29], [31]

	UNEP guidelines	SHDB databases	PSILCA databases
Developed	2009	2009	2013
Impact categories	• Worker • Local community • Value chain actors • Consumer • Society • Children	• Labor rights and decent work • Health and safety • Human rights • Governance • Community and infrastructure	• Workers • Local communities • Society • Value chain actors
Subcategories	40 subcategories	26 subcategories	19 subcategories
Indicators	Indicators with examples for data sources	Over 160 qualitative, quantitative, and se-mi-quantitative indicators	65 qualitative, quantitative, and se-mi-quantitative indicators
Industries	No restrictions	Coverage of about 13 000 country-specific industries	Coverage of about 15 000 country-specific industries
Countries	No restrictions	244 countries based on the GTAP input/output database	189 countries based on the Eora input/output database
Social impact	Social performance evaluation (+2 to -2) or Social risk evaluation (very high risks to low risk)	Medium risk hours equivalent (mrheq)	Medium risk hours equivalent (mrheq)

UNEP guidelines

UNEP guidelines provide consistent guidance to promote context-appropriate application to support S-LCA case studies [22]. The guidelines define the category of impact as well as policy relevance. The guidelines also include an inventory indicator with examples of data sources - databases, reports, interviews with insiders and other data sources [23].

Databases

The database contains general social data linking social risks to specific sectors in the country related to the assessed product or service [24]. The SHDB database has social risks and detailed information on supply chain human rights and working conditions to calculate social conditions and contribute to their improvement in the world [25]. The PSILCA database contains the social aspects of products, which are integrated into the global input/output model and this model reflects the structure of the world economy [7]. However, all the necessary indicators are not always available in the database [26]. PSILCA and SHDB databases uses the "working time" activity variable which refers to the number of hours required to produce

1 USD output [27]. For SHDB reference year for USD is 2011 and for PSILCA reference year for USD is 2015 [28], [29]. A limitation of the databases is that they do not accurately reflect the impact of the economic sector on social conditions, as many indicators show the situation in a country rather than in a sector [30]. Similarly, S-LCA methods can be divided from social sustainability objectives[20].

The main features were chosen according to what will be the benefit of these methods. It is very important what are the impact categories in which the results are obtained, as well as if necessary one of the categories may not be considered or one of the categories is not one of the stages of the life cycle. It is also important what indicators are used to obtain an impact assessment. There is also a difference between different industries and countries, so these criteria were also chosen.

Advantages and disadvantages for UNEP guidelines in **Figure 7** and the SHDB and PSILCA database in **Figure 8**. The advantage of the UNEP guidelines is the tailoring of indicators to the required situation, the disadvantage being the time-consuming assessment of social impacts and the need to benchmark for social assessment.

Advantages

- No program or license is required
- Wide distribution of indicators
- Adapting indicators with the aim of assessment
- Easy to use qualitative and quantitative data
- Social assessment results as performance or risk evaluation

Disadvantages

- Subjective risk assessment
- Time - consuming assessment
- Need benchmark or alternative to compare against
- Difficult to compare results with other results

Figure 7. Advantages and disadvantages of the UNEP guidelines

The advantage of the databases is that it is easy to obtain social impact results, and it is also possible for only one product/service. The disadvantage is that the input data must be in monetary terms and converted according to the database requirements.

Advantages

- Extensive database
- Wide distribution of indicators
- Standardized method - results can be compared
- Timesaving assessment
- Assessment can be done for a single product/service

Disadvantages

- Program and license required
- General distribution of industries
- Qualitative input data should be expressed in monetary values
- Qualitative input data must be converted to quantitative data

Figure 8. Advantages and disadvantages of SHDB and PSILCA databases

Looking at the advantages and disadvantages of the methods, they were divided according to whether a program and databases are needed, the distribution of indicators, what data can be used and what kind of result is obtained, and whether it is possible to compare with someone else's data.

Selecting the Social Life Cycle Assessment method

From the literature review on S-LCA assessment methods and the criteria that characterise them, a set of criteria was drawn up to help select the most appropriate and suitable method for assessing social impacts or social risks. In **Table 4** are criteria that can help to choose assessment method. One of the most important criteria is that the database methods require a program and a license, but the UNEP guidelines do not require such a requirement. An important criterion is the type of results obtained and the categories of results, so that it is consistent with the defined goal. Also, the type of input data and whether the necessary data on industry and countries are available is an important criterion to make an assessment. Another important criterion is the time consumption required for obtaining input data and performing the assessment.

Table 4. Criteria for selecting the S-LCA assessment method

Criteria	UNEP guidelines	SHDB and PSILCA databases
Special program and a database with a license are required	No	Yes
Input data type	Quantitative and/or qualitative	Monetary values
Input data source	Generic and/ or site-specific data	Generic and/ or site-specific data
Defined industries	No	Yes
Defined countries	No	Yes
Required time for S-LCA assessment	Time consuming	Timesaving assessment
Obtained result	Social performance or risk evaluation	Defined unit of measure (mrheq)
Comparing social impact/risk with the results of industry alternatives	Difficult because the assessment can be subjective	Simple because there is a standardized method

The criteria were chosen based on the literature review and the distribution of the most important indicators by advantages and disadvantages. Also, these would be the first criteria that help to understand which method corresponds to what is available from the data, which indicators and categories need to be monitored and the desired measure of impact.

CONCLUSIONS

In general, there are many and different methods for S-LCA evaluation, but these methods were chosen because these methods are more frequently encountered in different types of literature. In general, social impact assessment is not yet as popular as environmental impact assessment. However, the results of the bibliometric analysis of the fact that the number of publications is increasing, especially in Europe, show the tendency that more and more attention is being paid to social aspects.

S-LCA methods and databases are also being developed and refined to obtain a better assessment of social impact. Each method has a different way of specifying social impact and

each method has advantages and disadvantages that must be considered when choosing a method for a particular case. The advantage of the database (SHDB and PSILCA) is that results can be obtained for one product/service, and the assessment is obtained quickly, but in the UNEP guidelines, the assessment process is time-consuming, because of data search for indicators and need for benchmark or similar product or service values to compare. However, the advantage of UNEP guidelines is the type of input data must be appropriate in the criterion, therefore the joint assessment can be from quantitative and qualitative data, but the databases contain monetary values as input data, which must be converted to the USD value of the corresponding year. The main criteria for choosing an S-LCA assessment method are the type of input data, time consumption, access to the database and license, the type of outputs and results in the required categories, and the availability of the required industry or country profile.

Of course, there is still room for development and growth in the S-LCA assessment tools, for example to restore the input values in the SHDB and PSILCA database monitors, because it is necessary to transfer them to the 2011 USD value in SHDB, and to the 2015 USD value in PSILCA, the categories could still be supplemented with a little more specific distribution. The UNEP guidelines method could be improved with recommendations for sectors, as there are currently recommendations on data sources. The UNEP guideline method takes much more time, directly because of the data search and then its evaluation, than it is when using one of the databases, where you enter values and select the results method and the program performs calculations to obtain the results.

Further research could be related to social impact, a deeper sector analysis of what categories and indicators are used and what social impact has been achieved. Social impact assessment is becoming more and more popular, as assessment tools are being developed, the first social product declaration has been published and, in general, it is necessary to think in all three dimensions of sustainability - environmental, economic and social.

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