

Social Life Cycle Assessment – A Bibliometric Review

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Abstract

This article presents a bibliometric analysis of social life cycle assessment (S-LCA), which has gained importance due to the need to know the social impact of business operations on persons. Using the PRISMA methodology, we identified 190 documents regarding SLCA in the SCOPUS database and were analyzed with the VOSviewer software. Specifically, the most cited documents, authors, organizations, and countries are analyzed and the most productive according to the number published. This analysis included the most used keywords are analyzed on the S-LCA topic. Findings indicate that this topic has become relevant since 2007, and currently, the number of scientific publications has an exponential trend. It has been identified that Traverso M. is the author who has 19 products with 603 citations; however, Guyton R.A. is the most cited author with only two papers and 813 citations. The institution that publishes the most on this topic is the Universidad Rey Juan Carlos (Spain), with three papers and 108 citations. Authors from 46 countries were identified, but the most productive are Italy and Germany, and the most cited are the United States of America and Germany. A total of 1625 keywords were identified, but life cycle assessment, social life cycle assessment, and sustainable development are the most used.

Keywords

Social life cycle assessment, bibliometric review, SLCA, SCOPUS, Database.

1. Introduction

The life cycle assessment (LCA) of a product is a methodology that identifies, quantifies, and characterizes the different environmental impacts associated with each of the stages of a product's life cycle (Rodríguez, 2003), which agrees with Eurofins (2021), who adds the potential impacts of any activity to the LCA concept. Therefore, the LCA makes it possible to know the critical operations of the production processes and thus seek alternative solutions that contribute to and promote sustainable production from an environmental approach.

One of these potential impacts is the human factor, so LCA now integrates the social aspect, called social life cycle assessment (S-LCA). Research on S-LCA has increased and gained international academic and scientific acceptance in recent decades. S-LCA is defined by Huertas-Valdivia, Ferrari, Settembre-Blundo, and García-Muiña (2020) as "a technique for collecting, analyzing and communicating information on the social conditions and impacts associated with production and consumption."

The LCA methodology is regulated by ISO 14040. According to this standard, when analyzing the environmental aspects and potential environmental impacts throughout the life cycle of a product, the following activities must be carried out:

1. Compile an inventory of relevant inputs and outputs of the product system, those include the energy and raw material.
2. Evaluate the potential environmental impacts associated with the inputs and outputs identified in the inventory.
3. Interpret the results of the inventory analysis and evaluation phases by the study's objectives and propose new improvement to production process.

Concerning the ISO 14040 standard, LCA-S consists of four main stages that refer to the definition of the objective and scope, the life cycle inventory analysis, the life cycle impact assessment, and the interpretation of the analysis performed. A review of the number of scientific papers on LCA-S shows exponential growth, so it is considered a topic of scientific interest. It is necessary to identify the leading research groups, authors' institutional affiliations, and citations, and it can be done through a bibliometric analysis.

Solano López, Castellanos Quintero, López Rodríguez del Rey, and Hernández Fernández (2009) describe bibliometrics as applying mathematics, and statistical methods to any written source based on the facets of communication and considers elements such as authors, the title of the publication type of document, language, abstract, and keywords or descriptors. In other words, bibliometric indicators are statistical data deduced from the different characteristics of scientific publications (Fernández, 2016) and provide quantitative and objective information on the results of the research process, its volume, evolution, visibility and structure. However, they do not report on the progress of knowledge.

With this type of analysis, indicators are obtained, such as the number of publications during a given period, languages, the disciplines in which work is done, and the number of authors, institutions, or countries participating in the documents. Currently, there are bibliometric reviews of LCA applied to fields such as the environment, sustainable materials, civil engineering, and the medical sector, where social aspects have not been integrated. For example, in the sustainable materials sector, Moghayedi, Le Jeune, Massyn, and Byron (2022) report research on sustainable building materials and propose a conceptual framework for developing sustainable building materials.

Bezama, Mittelstädt, Thrän, and Balkau (2021) report a bibliometric analysis of trends and challenges in LCA management, using the Scopus database and integrating a co-word analysis to highlight essential links. The results indicate that an increasing number of articles on LCA have been published in recent years; however, the focus continues to be on materials-oriented issues. Ramos, De Paula Lacerda Santos, and Maceno (2019) identified and characterized comparative LCA studies between conventional and prefabricated building systems in Europe and Asia and indicate that the construction industry is responsible for considerable environmental impacts from raw material extraction to demolition, pointing out the main causative processes.

Huertas-Valdivia et al. (2020) are the first to report a bibliometric analysis of S-LCA and review publications from 2003 to 2018 (Figure 1). The authors describe the structure and trends in S-LCA publications in terms related to authors, journals, countries, most cited articles, and subject categories; however, after four years of research, an update of this type of study is required, and Figure 1 illustrates an exponential growth until the year 2021, according to the quadratic trend line that has been fitted and appears in red. This article aims to present a bibliometric analysis of the LCA-S applied in the productive sector to know which countries, organizations, journals, and institutions publish the most, which authors do so, and which are currently the most cited. For this reason, this article reports the results of the second stage of a project focused on conducting an LCA-S in the Mexican maquiladora industry sector.

This article is divided into four sections. The first section presents an introduction to the concepts of LCA and LCA-S and describes the importance of the subject. The second section illustrates the methodology followed to perform the bibliometric analysis, such as the PRISMA method for identifying bibliographic references and the VOSviewer software for their analysis. The third section reports the results found according to the bibliometrics analyzed and, finally, the conclusions that discuss the trends that this research topic may have been mentioned.

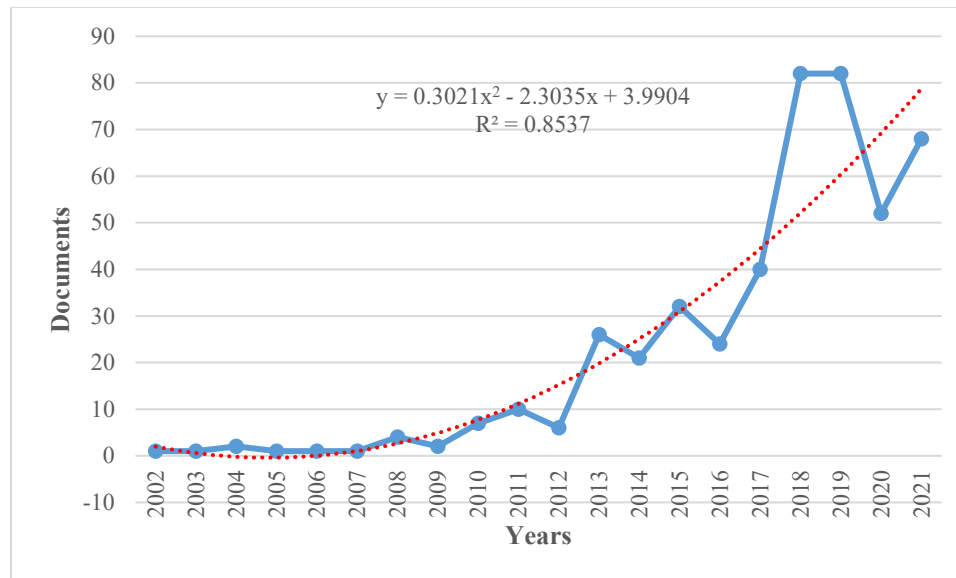


Figure 1. Timeline for S-LCA documents

2. Methodology

2.1 Identification of references

The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) methodology is used to identify references associated with LCA-S, defined by Hutton, Catalá-López, and Moher (2016) as a research publication guide designed to improve the completeness of the reporting of systematic reviews and meta-analyses. PRISMA has been widely accepted; for example, Kim and So (2022) use it to analyze customer experience in the tourism industry, while Baarimah et al. (2022) use it to analyze building information modeling and reconstruction after a catastrophe.

Figure 2 illustrates the PRISMA methodology, divided into four stages for its execution (Gerard Urrutia, 2010). The SCOPUS, ELSEVIER, and DIMENSIONS databases were used to identify the bibliographic references. The search equation was (TITLE-ABS-KEY ("social life cycle assessment") OR TITLE-ABS-KEY ("Social Life Cycle Assessment") OR TITLE-ABS-KEY (S-LCA)), where 195 documents were identified in SCOPUS in ELSEVIER and DIMENSIONS. A file with RIS extension is downloaded from each of these databases with a list of references. Those files are integrated into the Endnote 8.0 software, with 228 references for initial analysis, but after eliminating 20 duplicates, only 208 remain. However, only the English language documents are analyzed, which can be articles or book chapters, where a discussion of the results found is reported, which allows eliminating ten more documents, leaving only 198, of which only 190 are full text, and those are analyzed.

2.2 Analysis of references

The 190 papers are analyzed in the VOSviewer 1.6.17 software since it can be used free of charge and has been employed in other scientific articles (Zhang, Yang, Zhang, Liu, & Yun, 2022). In addition, VOSviewer allows the creation of visual and bibliometric maps that are intuitive (van Eck & Waltman, 2010).

The data analysis focuses on determining the following:

1. The principal authors, institutions, and countries they are affiliated .
2. The main keywords used for indexing all publishing documents regarding S-LCA.
3. The most cited documents, sources, authors, institutions, and countries in the ACS-S topic.
4. A series of bibliographic maps that visually support the relationships between authors, institutions, and countries are also reported.

3. Results

3.1 Los autores que investigan S-LCA

Six hundred four authors were identified who published a paper on LCA-S; however, many have only one paper. The most important authors according to the number of documents generated are Traverso, M. with 19, Ciroth, A., Ferrari, A.M. and Ugaya with 6, Finkbeiner M., Petti L. with 5, Achten W.M.J., Corona B., De Luca A.I., Sureau S., Ugaya C. and Valdivia S. with 4, Backes J.G., Ekener-Petersen E., Falcone G., Gheewala S.H., Iofrida N., Karakoyun F., Kiritsis D., Mazijn B., Norris G.A., Pini M., Prasara-A J., Rieradevall J., San Miguel G., Settembre-Blundo D., Sharaai A.H., Tsalidis G.A. and Zamagni A. with 3. It can be observed that Traverso can be considered the guru in this research area since he triples the number of products of the authors in second place. Figure 3 illustrates the relationships that these authors have, and they have been grouped into 18 clusters, where Traverso, M. and Finkbeiner, M. are the authors who are most related to others.

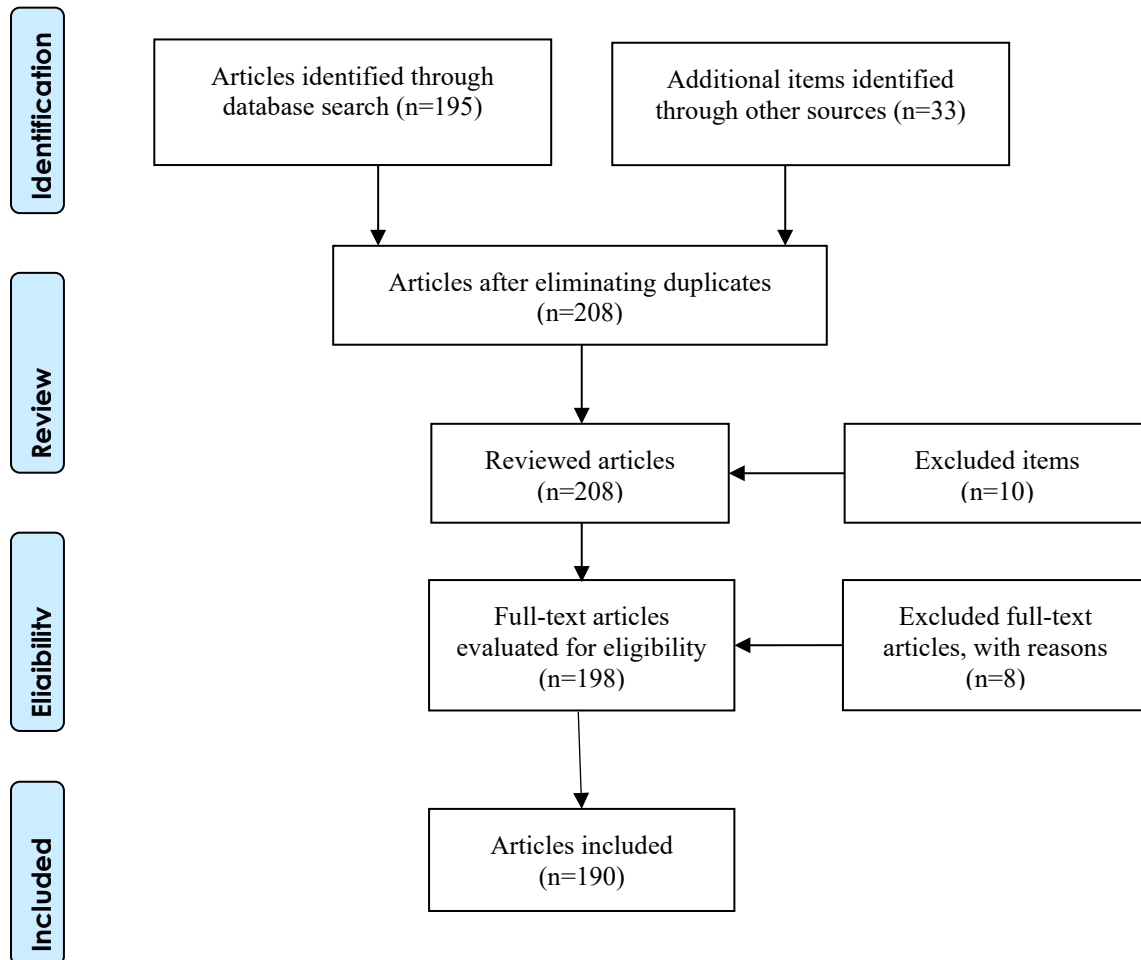


Figure 2. PRISMA applied to S-LCA

3.2 Institutions investigating S-LCA

Four hundred forty-nine different authors publishing on S-LCA were identified, as sometimes different departments or academic units are considered separately. However, different departments or academic units in the same university are considered the same institution for our analysis.

The results indicate that RWTH Aachen University (Germany) has six papers, the University of Hong Kong (Hong Kong) has 4, Rey Juan Carlos University (Spain) has 3. In contrast, University of Coimbra (Portugal), BMW Group (Germany), University of Aveiro (Portugal), University of Catania (Italy), University of Modena and Reggio Emilia (Italy), University of Mauritius (Mauritius), Universiti Putra Malaysia (Malaysia), Gruppo Ceramiche Gresmalt (Italy), Université Libre de Bruxelles (Belgium), Mediterranean University of Reggio Emilia (Italy), Mediterranean University of Reggio Emilia (Italy), University of Mauritius (Mauritius), Universiti Putra Malaysia (Malaysia),

Gruppo Ceramiche Gresmalt (Italy), Université Libre de Bruxelles (Belgium), Mediterranean University of Reggio Calabria (Italy), University of Montpellier (France) and Uncastillo Foundation Uncastillo (Spain) have two documents, so it can be said that these are the pioneering universities (Figure 3). However, 430 institutions have only one published document and are starting to strengthen their research groups in this topic of S-LCA.

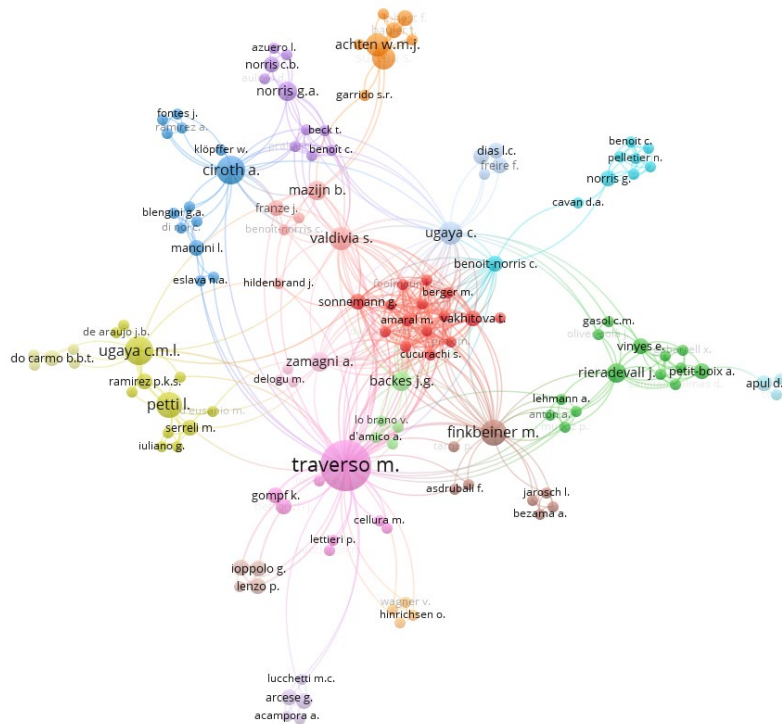


Figure 3. Authors relationships

From the above list, European institutions are the leaders in this topic since there are no American, African, or Oceania institutions. However, the University of Hong Kong appears to represent Asia. In addition, an analysis of the relationships between institutions shows that there are only two clusters, the first one grouping German institutions and the other all the others.

3.3 Countries in which LCA-S is being investigated

A total of 48 countries have published on S-LCA, although this does not indicate that they are the most referenced, but rather that they have generated the most papers. Figure 4 illustrates the top ten countries and the number of papers they have published. In this case, the first three countries are European and that the Americas are represented by the United States, Canada, and Brazil, while China represents Asia. It is essential to mention that these European countries are also the most cited.

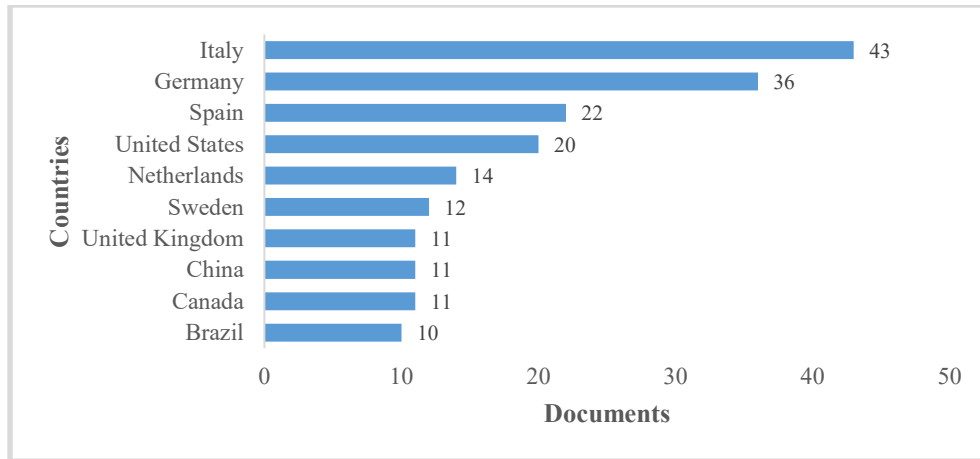


Figure 4. Main countries publishing on S-LCA

Figure 5 illustrates the relationships between countries, showing those with at least two published papers. At the bottom, a time scale is observed, where the purple color represents the countries that have been publishing on S-LCA for the most years and the yellow ones are the most recent countries. In this case, countries such as the United States, France, Brazil, and Sweden are the oldest. In contrast, the green countries represent countries that already have a tradition in this topic and are represented by Italy, Germany, Spain, China, and Denmark, some of which have also published the most. Finally, the countries in yellow are beginning to research S-LCA, such as Malaysia, Portugal, and the Netherlands.

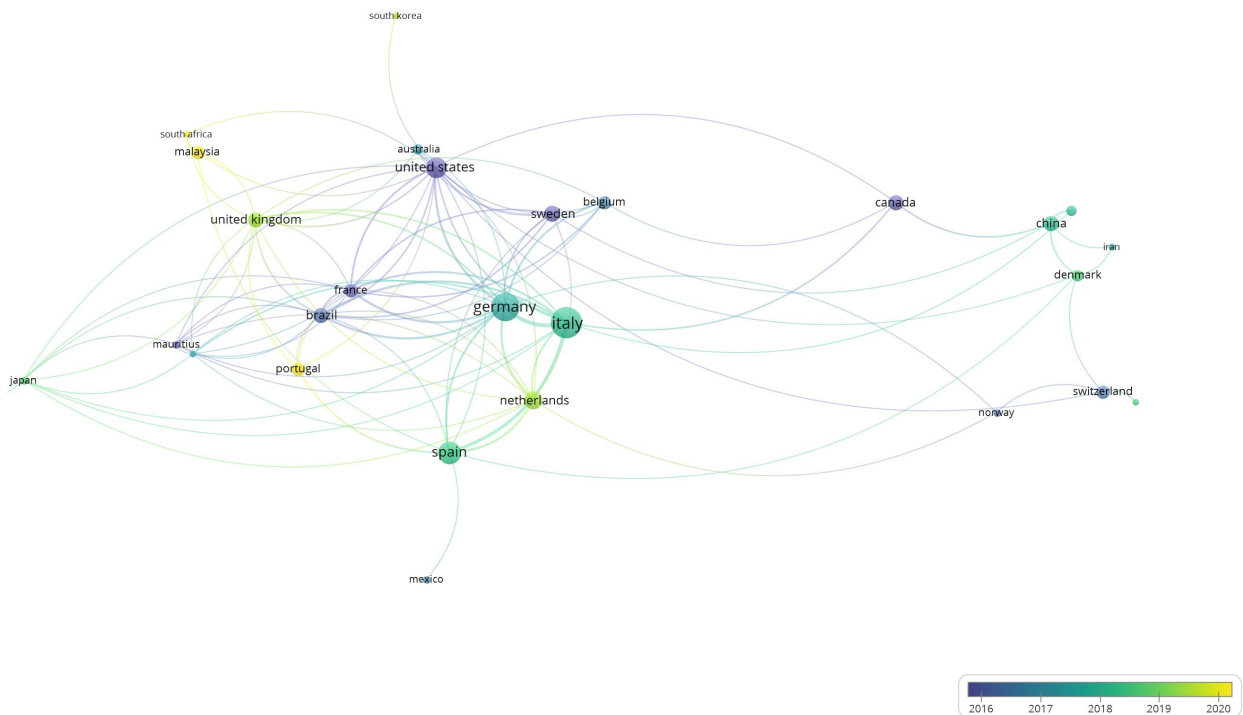


Figure 5. Countries publishing on SLCA

3.4 Most used words for indexing S-LCA documents

The most used keywords for indexing documents on LCA-S have been analyzed. Five hundred sixty-one different words were counted grouped into 51 clusters, making their analysis difficult. Figure 6 illustrates the 41 most used words mentioned at least three times, integrated into 7 clusters, and facilitated their relationship and analysis. The

top ten most used words are social life cycle assessment (134), sustainability (37), life cycle assessment (45), life cycle sustainability assessment (10), social impacts (10), lca (9), social sustainability (9), stakeholders (8), life cycle costing (7) and supply chain (7).

3.5 Most cited papers on S-LCA

Not all the articles generated in S-LCA have had the same impact on the scientific community (figure 6), and few have served as a basis for other research, which is why they have been referenced. Of the articles analyzed, some have only one citation. However, the most referenced are those listed below: Kin et al. (2004) with 538, Kin et al. (2005) with 284, (Benoit et al., 2010) with 271, Martínez-Blanco et al. (2014) with 146, Benoit-Norris, Cavan, and Norris (2012) with 145, Spierling et al. (2018) with 122, Valdivia et al. (2013) with 119, Traverso, Asdrubali, Francia, and Finkbeiner (2012) with 115, (Hosseinijou, Mansour, & Shirazi, 2014) with 114, among others.

From the above, it is observed that Traverso is the author with the most published papers, but only one of them is in the top ten of those cited. In this case, the two most cited papers are associated with cardiac problems of workers and their health in general terms. Figure 7 illustrates the relationships between the most cited papers, where these are fully established authors since most of those in the top ten are in purple.

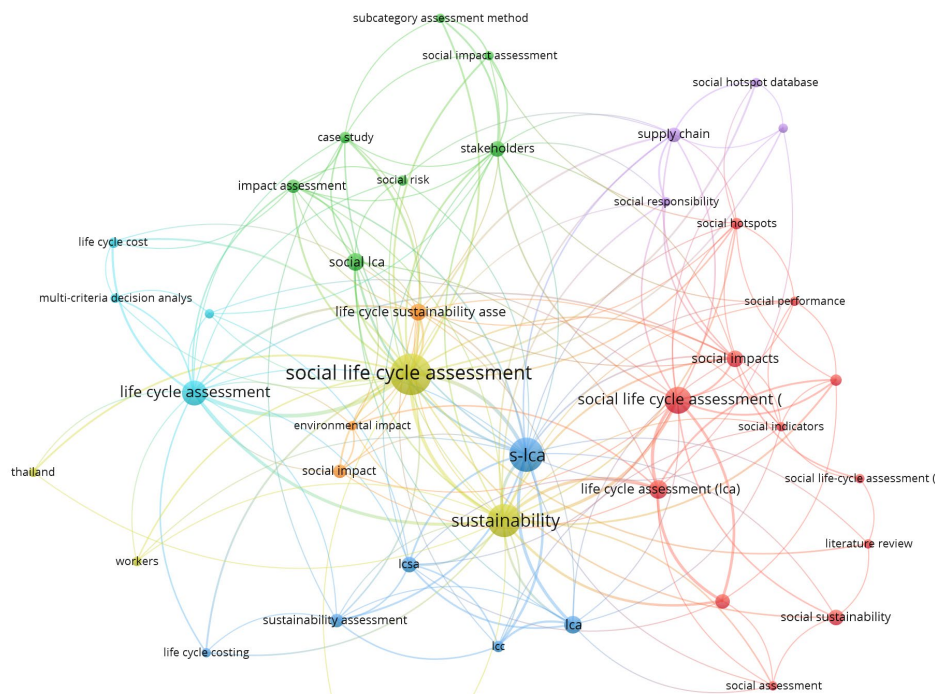


Figure 6. Keywords in S-LCA

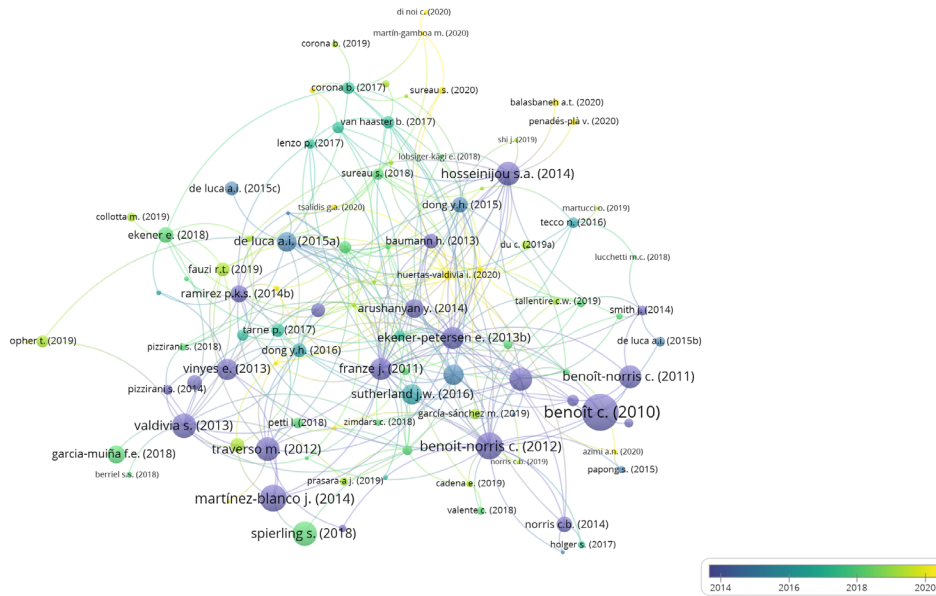


Figure 7. Relationships among most cited documents

3.6 Most cited journals on LCA-S

Although journals specialized in LCA and S-LCA appear for attending this topic, others have been added to the list of published sources. Eighty-one journals or sources published on this topic were identified integrated into 20 clusters. Figure 8 illustrates the top ten journals. The International Journal of Life Cycle Assessment, which is very specialized, leads the list, followed by Cardiovascular Research and the Journal of Cleaner Production.

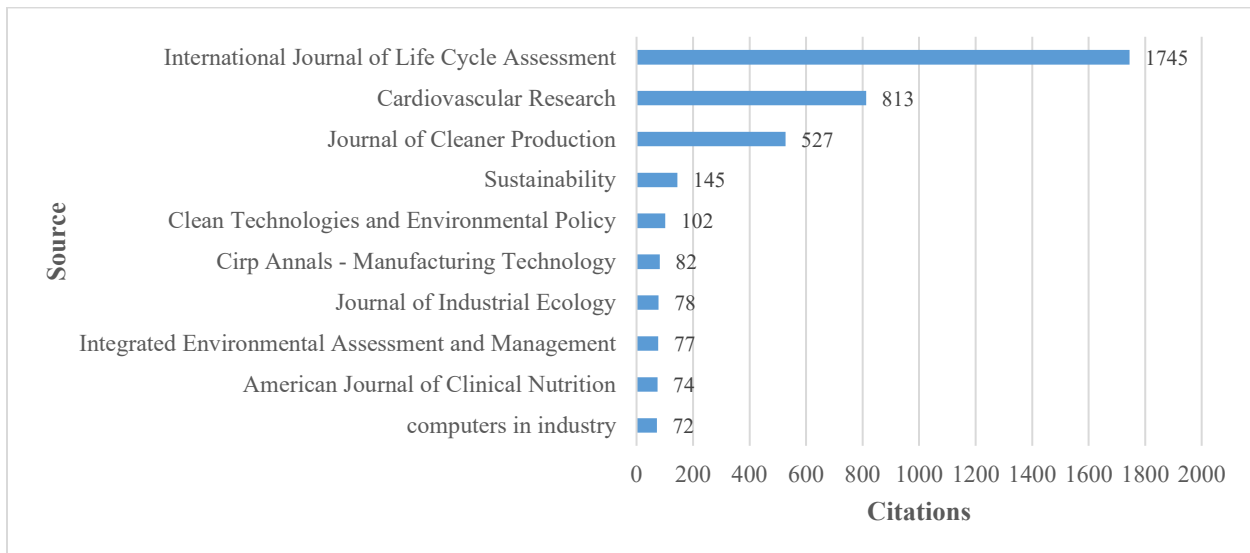


Figure 8. The top ten of sources publishing on S-LCA

Figure 9 illustrates the relationship between the different sources or journals. The International Journal of Life Cycle Assessment, Sustainability, the Journal of Cleaner Production and Resources are the journals that have been published on this topic for the most years are therefore the most cited. However, some journals are beginning to publish on this topic and are already cited, such as Resources or Energies.

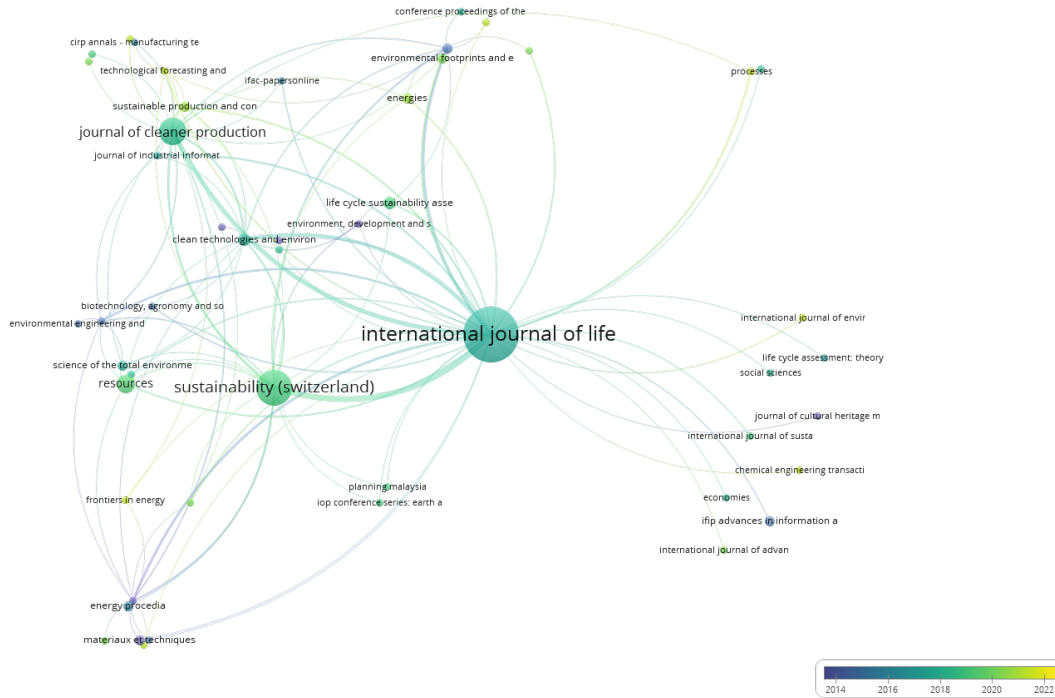


Figure 9. Relationships among Sources

3.7 Most cited authors on S-LCA

We identified 464 authors with at least one citation to their papers, grouped into 17 clusters. The most cited authors in the LCA-S topic are Guyton, R.A., Halkos, M.E., Kin, H., Vinten-Johansen, J., Zhao, Z.-O., Traverso, M., Ugaya, C., Citroth, A., Corvera, J.S., Sun, H.-Y. Figure 10 illustrates some of these authors, although it is important to mention that these citations refer to the total and not a specific paper.

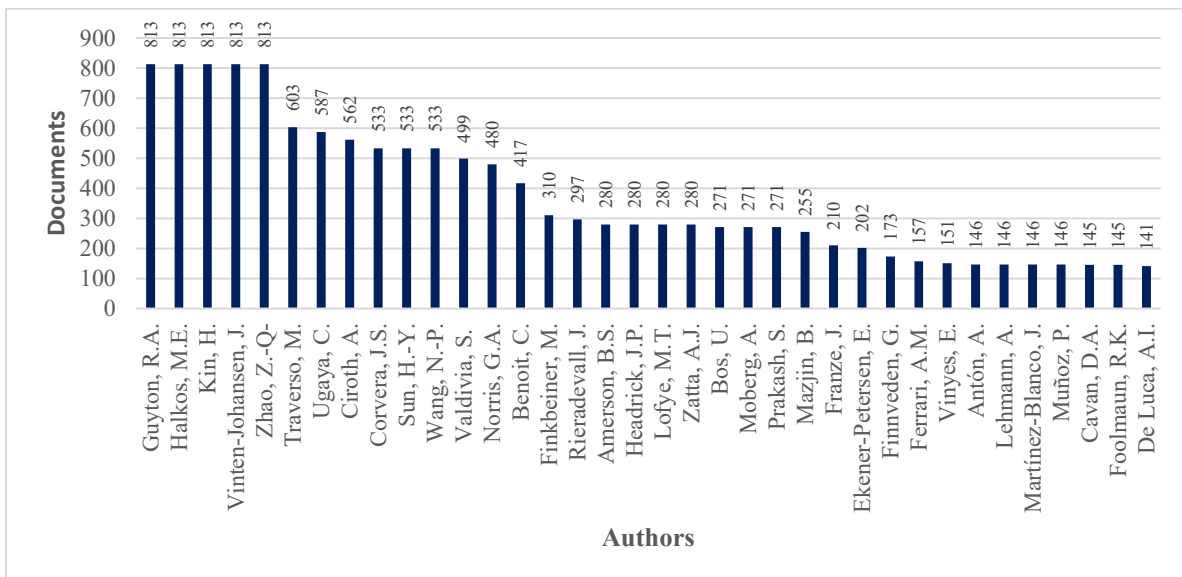


Figure 10. Most cited authors

3.8 Most cited institutions on S-LCA

To determine the importance of the research groups in each institution, the total number of citations they receive is analyzed, including all the groups and units that comprise them. In this case, Emory University has 1346 (United

States), Griffith University has 280 (Australia), Universität Stuttgart (Germany), Greendelta TC (Germany), Royal Institute of Technology (Sweden), Oeko Institute (Germany), University Of New Hampshire (United States), University of Arkansas (United States), United Nations Environment Programme (France) and Universidade Tecnológica Federal Do Paraná (Brazil) have 271, while Universitat Autònoma De Barcelona (Spain) and Universitat Rovira I Virgili (Spain) have 146.

3.9 Most cited countries on S-LCA

Figure 11 illustrates the number of citations by country, where only the residence of the principal author has been considered. A total of 42 countries can be observed, of which the United States stands out with a total of 1604 citations; it can also be seen that, of these 42 countries, 19 are European, which represents 45% of the entire analysis and indicates that they are pioneers in research related to this methodology. Of the 42 countries with citations on S-LCA, only the United States of America, Mexico, Canada, Cuba, Chile, and Brazil represent the Americas. However, they accumulate 2,559 citations between them and represent 19% of the total number of countries.

Figure 12 shows the citation ratios between countries and the time scale at the bottom. Countries such as the United States of America, Canada, Belgium, and Sweden have been cited for a long time. However, countries such as Italy, Germany, and Spain are also beginning to consolidate, and finally, emerging countries such as Malaysia, Portugal, South Africa, Costa Rica, Chile, and Lithuania are observed.

4. Conclusions

The publication of scientific papers associated with S-LCA has increased exponentially in recent years due to the concern that social aspects are having in working environments, and many countries are demonstrating this. After the bibliometric analysis, it has been found that Traverso, M., Citroth A., Ferrari A.M., Ugaya C.M.L., Finkbeiner M., and Petti L. are the outstanding authors in this topic concerning the number of documents generated. However, when analyzing the production of documents by institution, it is found that RWTH Aachen University in Germany, the University of Hong Kong, and Rey Juan Carlos University in Spain are in the lead. When all the institutions are unified to integrate them into countries, it is found that Italy, Germany, Spain and the United States of America, Holland, and Sweden produce the most documents (Figure 11 and figure 12).

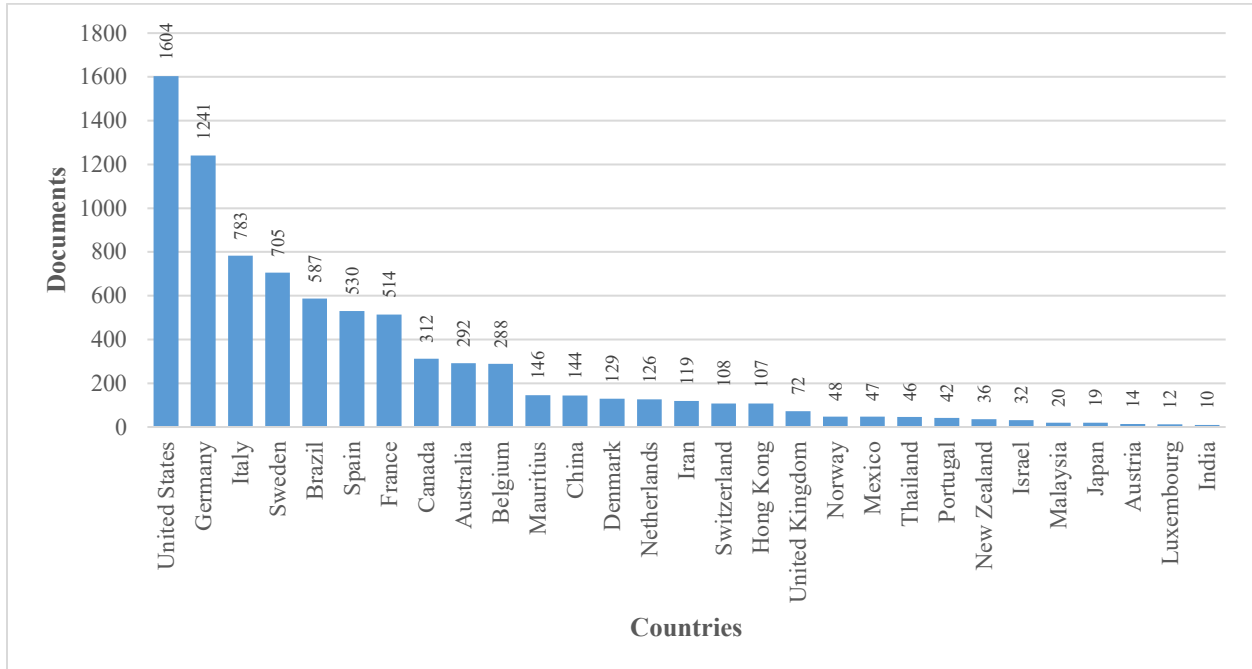


Figure 11. Most cited countries on S-LCA

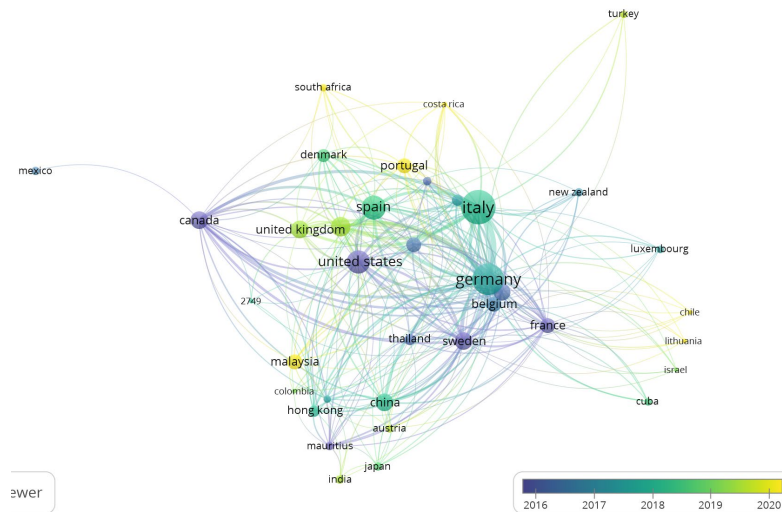


Figure 12. Relationship among cited counties in SLCA

From the analysis of the words used to index the documents, it is concluded that social life cycle assessment, sustainability, life cycle assessment, life cycle sustainability assessment, and social impacts are the most used.

Perhaps because it is the most published journal on this topic, the International Journal of Life Cycle Assessment and the Journal of Cleaner Production is the most cited on S-LCA. On the other hand, the most cited authors are Guyton, R.A., Halkos, M.E., Kin, H., among others. However, to institutions, the most cited are Emory University (United States), Griffith University (Australia), Universität Stuttgart (Germany), Greendelta TC (Germany), and the Royal Institute of Technology (Sweden). The most cited are the United States of America, Germany, Italy, Sweden, Brazil, and Spain when integrating these institutions.

Given the above, Latin American, and African countries have very few publications and citations; however, they are centers where outsourced manufacturing operations are carried out, so it is convenient to start studying the social impact of industrial operations in those countries.

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