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Article

Life Cycle Approaches for the Environmental Impact Assessment of Organizations: Defining the State of the Art

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Abstract: Organizations play a key role in reducing anthropogenic pressure on the natural environment. The first step towards improving their sustainability performances is the implementation of methodologies that take into consideration multiple environmental impact categories, as well as the entire value chain. The attention of scholars and practitioners was initially addressed to the analysis of products and processes, yet in a few cases in which they were addressed, the approaches used for organizations had a limited scope and range of use. Only in recent years have they been framed in a life cycle perspective. This article analyzes two recent life cycle-based methodologies that have their focus on the organization, namely Organization Environmental Footprint (OEF) and Organizational Life Cycle Assessment (O-LCA). The goal is to define the state of the art of their methodological and current application developments and consider the relevance that these methodologies can have, both in terms of internal and external commitment (e.g., for the supply chain actors) and of reporting and communication requirements. The research was carried out starting from scientific databases, integrating technical legislation and secondary literature. The results obtained allowed tracing the first evolutionary trends, identifying the main authors and scientific journals and highlighting the relevant issues according to the researchers. A content and bibliometric analysis was performed that included all the contributions published so far. Projects and case studies that practically applied the two methodologies were also identified and analyzed. Finally, the main differences between the two methodologies were highlighted and future developments were hypothesized.

Keywords: Organisation Environmental Footprint (OEF); organizational life cycle assessment (O-LCA); ISO/TS 14072

1. Introduction

In 2002, the World Summit on Sustainable Development (WSSD) was held in Johannesburg, South Africa and encouraged a series of programs that focused on sustainable production and consumption. As a result, great efforts have been made to develop methods, techniques, and tools to evaluate, compare, and communicate the environmental performance of products and services (Martínez-Blanco et al. 2016). The life cycle perspective and related approaches have progressively established themselves as the most effective in order to capture the totality of the impacts of products, processes, and services, starting from the extraction of raw materials to get to end of life (ISO 2006a, 2006b). The same attention was not paid to organizations that can play a key role in reducing pressure on the environment. In order to take credible steps in that direction, they need stable

frameworks and effective tools capable of framing decisions and strategies including aspects that are not only economic and technical (UNEP/SETAC 2015).

Until a few years ago, there were no methodologies available that simultaneously followed an organizational, life cycle, and multi-criteria approach. The first reference model was the environmental management system (EMS), which can be certified according to the ISO 14001 standard or the European Eco-Management and Audit Scheme (EMAS) regulation. However, both follow a procedural approach and are focused on the processes that take place within the company boundaries (UNEP/SETAC 2015). More recently, some methods emerged to carry out environmental analyses at the corporate level; among them, the carbon footprint calculations proposed by the protocol on greenhouse gases, ISO/TR 14069, Carbon Disclosure Project, Bilan Carbone, or DEFRA. Climate change revealed to be at the center of attention and concerns. The first initiative to apply the life cycle approach at the organizational level was, in fact, the protocol on greenhouse gases (Manzardo et al. 2016). Moreover, some other initiatives that have tried to investigate the application of the assessment methodology of products/processes-especially based on life cycle assessment in broader contexts, such as organizations, must be recognized (e.g., Finkbeiner et al. 1998; Pflieger et al. 2005; Cluzel et al. 2012). However, they have not found, at least in a first period, formalization in standardized procedures. Other minor experiences focused on a single aspect or environmental indicator and place greater emphasis on the implementation of sustainability reports rather than on how to measure and manage the organization's environmental performance (Martínez-Blanco et al. 2016). Nevertheless, it must be recognized that the studies in question have greatly contributed to promoting and testing the application of assessment tools in organizational contexts (UNEP/SETAC 2015).

The Organisation Environmental Footprint (OEF) (European Commission 2013) and Organizational Life Cycle Assessment (O-LCA) (ISO 2014) represent an important advance in that sense, as they are designed to support decision-making processes and strategies, including technical-economic and environmental aspects, as well as consider multiple categories of impact along the entire value chain. Such organizational approaches reveal among all products and operations the critical points where the organization should concentrate interventions and energies (Martínez-Blanco et al. 2016). These methodologies can play an important role for companies and markets and, more generally, economic and social stakeholders because they are able to highlight the commitment to the sustainability issues of entire organizations and supply chains. Moreover, this occurs through the reporting and communication initiatives (e.g., sustainability reports), which increasingly include the environmental performances obtained.

In this article, we propose an analysis of the scientific contributions and the applicative examples of the two methodologies, with the objectives of tracing the state of the art of the studies and the evolutionary trends, highlighting their potential limits and making a comparison between the two approaches. This type of comparative analysis has already been used in similar fields, for example by Lehmann et al. to compare in one case ISO 14000 and Product Environmental Footprint (PEF) (Lehmann et al. 2015) or Life Cycle Assessment methodology and product environmental footprint methodology (Lehmann et al. 2016). In both cases, the results obtained have proved useful for highlighting critical issues, potentialities, and application limits of the analyzed approaches.

The following section of the article proposes an overview of the two methodologies; section three highlights the methods followed; section four the scientific and the practical results obtained; section five discusses the results; section six draws conclusions.

2. Overview of the Two Methodologies

2.1. The Organisation Environmental Footprint

The OEF is a methodology developed by the joint research center (JRC) and other bodies of the European Commission. They worked on developing the OEF Guide, a technical guide for calculating the environmental footprint of organizations, elaborating in parallel the PEF was devoted

to products (European Commission 2013). The two methodologies are closely related. The OEF Guide purpose is to increase the reproducibility and comparability of the studies emphasizing the principle "comparability over flexibility" to ensure that the methodology is consistently applied (Martínez-Blanco et al. 2016). The OEF was developed based on the international reference life cycle data system handbook (European Commission, Joint Research Centre, Institute for Environment and Sustainability European Commission–JRC–IES) and other existing methodological standards, including ISO 14069, and the corporate value chain (Scope 3) standard. In addition, it took into account the results of a preliminary pilot phase, an expert consultation, and a consultation among the European Commission bodies. Once the guideline was drawn up, this was tested through pilot studies on selected sectors for further verification and to prepare the corresponding sectorial rules (OEFSRs) (Martínez-Blanco et al. 2016).

2.2. The Organizational Life Cycle Assessment

The O-LCA methodology is regulated by the technical standard ISO/TS 14072 (ISO 2014) and is the subject of the guidance on organizational Life Cycle Assessment developed by UNEP/SETAC (2015). The standard extends the application of ISO 14040 and ISO 14044 to all the activities of an organization by also providing requirements and additional guidelines to make their implementation easier and more effective (Martínez-Blanco et al. 2016). The UNEP/SETAC guideline foresees different implementation pathways that organizations can follow based on the previous experience gained with the tools and methodologies available in the environmental field. In addition, it provides specific recommendations to small, medium, and large organizations to shape ways of proceeding based on the needs that arise according to their size (UNEP/SETAC 2015).

3. Materials and Methods

The study conducted was aimed at outlining the state of the art of scientific knowledge and practical applications of methodologies for assessing the environmental impact of organizations. An unstructured preliminary check was conducted to verify whether any contributions matching the above-mentioned characteristics had been published previous to the appearance of the OEF and O-LCA methodologies. However, as also specified above, no structured or formalized initiatives have been identified that could be recognized as universally applicable. Therefore, it was decided to focus the study on the period from January 2013 to September 2019, years of elaboration and dissemination of the OEF and O-LCA methodologies.

The systematic literature analysis conducted was performed by consulting bibliographic databases and web search tools. Bibliographic analysis is useful to evaluate a search from both a quantitative and qualitative point of view, to identify a trend and to assess the impacts it can generate on people and organizations (Nilaranjan and Pushpanjali 2014; Yu et al. 2013). The following set of keywords was used to conduct the search: "OEF; Organization Footprint; Organisation Environmental Footprint; OLCA; O-LCA; Organizational LCA; Organizational Life Cycle Assessment". In order to avoid possible overlaps and duplications with related themes, the concepts composed of more than one word were linked with an underscore in order to limit the presence of works unrelated to the subject of analysis.

The method used started with searching for the keywords mentioned in the article title, abstract, and keywords, using the Scopus scientific database. Scopus, produced by Elsevier, is the biggest provider of multi-disciplinary bibliographic contents in the world, covering about 22,000 peer-reviewed journals, on which over 5000 international publishers work (Elsevier 2019). Once the search on Scopus was completed, other databases were also consulted, such as the Web of Science (2019), and JSTOR (2019), in order to verify if all published articles on the methodologies under analysis were found. No further articles were identified. In total, 20 journal articles, 4 technical/official documents (European Commission 2013; ISO 2014; UNEP/SETAC 2015, 2017), and 2 book chapters (Manzardo et al. 2016; Martínez-Blanco et al. 2016) were found. Therefore, it was possible to solve manually duplication problems and analyze all of them.

Initially, the results obtained were processed from the quantitative-bibliometric point of view, taking into consideration the following parameters: year of publication, journal, authors, and keywords. The data collected was used as a basis for the creation of tables, diagrams, and a network analysis.

Network analyses focus on relations among interacting units (e.g., individuals or organizations), that allow researchers to characterize and describe the features of networks and the role of units (Wasserman and Faust 1994; Yu et al. 2013). In this study, the network analysis approach has been used to investigate the relevance and the relationships among the nodes represented by the key concepts used in the various articles. In particular, the recurrence or the co-occurrence of some concepts rather than others is a descriptive measure of which issues have prevailed up to now in these studies and in what perspective they are investigated (Taddeo et al. 2019). The data collected has been processed by the Ucinet software (Borgatti et al. 2002) for the additional purposes of the analysis.

Subsequently, the contributions were subjected to a systematic content analysis to highlight the main contributions, existing gaps, applicative examples, and compare the two methodologies. In order to allow a better comprehension and comparison of the various articles examined, a set of key themes (and sub themes) was defined, based on which the articles have been reclassified so as to highlight the prevailing arguments. The mentioned set of key themes was identified by—using a content analysis—a recurrence of concepts in the titles, in the abstracts, and in the keywords. That analysis was conducted using an on-line word-count site (Wordcounter 2019); any duplication of concepts in the same article were removed. The results of the analysis are shown in Tables 3 and 4.

The section of the analysis concerning the applicative aspects of OEF and O-LCA also used technical reports, secondary literature, and website analysis in order to detect projects and case studies developed so far.

4. Results

4.1. State of the Art of Scientific Production

Despite the relatively short time frame covered by the research, a significant number of contributions dealing with the study of the two methodologies emerged: 20 scientific articles, 4 technical/official documents (European Commission 2013; ISO 2014; UNEP/SETAC 2015, 2017), and 2 book chapters (Manzardo et al. 2016; Martínez-Blanco et al. 2016) were identified. They have different aims (presentation, methodological development, analysis of case studies, comparison), but none of them has yet carried out an exhaustive picture of the first outcomes. Analyzing the five years that research was conducted, it is possible to highlight a quite marked interest in the topic and certainly growing potential. In the following tables (Tables 1 and 2), the scientific articles respectively related to OEF and O-LCA are listed. The result of the bibliometric and content analysis are then presented and discussed.

4.2. Evolutionary Trends

Considering the content of the articles and the year of publication, it is possible to notice a fairly constant trend for each of the methodologies. The first articles were published in 2014 and concern the OEF. This is justified by the fact that this methodology was born one year before the other. The trend from 2015 onwards seems to demonstrate, instead, a greater interest of researchers towards the O-LCA. In fact, other than 2017, the number of contributions dedicated to it is always greater than the number of contributions dedicated to the OEF.

Table 1. Scientific articles related to the Organisation Environmental Footprint (OEF).

Year	Source	Title	Authors
2018	J Ind Ecol	*Organization Environmental Footprint through Input-Output Analysis. A case study in the construction sector*	Martinez, S., Delgado, M., Martinez Marin, R., Alvarez, S.
2018	Ecotoxicol Environ Saf	*The role of bioassays in the evaluation of ecotoxicological aspects within the PEF/OEF protocols: The case of WWTPs*	Pedrazzani, R., Cavallotti, I., Bollati, E., Ferreri, M., Bertanza, G.
2018	Sci Total Environ	*Organization environmental footprint applying a multi-regional input-output analysis: A case study of a wood parquet company in Spain*	Martinez, S., Marchamalo, M., Alvarez, S.
2017	Int J Life Cycle Assess	*Using the product environmental footprint for supply chain management: lessons learned from a case study on pork*	Six, L., De Wilde, B., Vermeiren, F., Van Hemelryck, S., Vercaeren, M., Zamagni, A., (. . .), De Meester, S.
2017	J Clean Prod	*Organizational Environmental Footprint in German construction companies*	Neppach, S., Nunes, K. R., Schebek, L.
2015	Integr Environ Assess Manag	*Product Environmental Footprint in Policy and Market Decisions: Applicability and Impact Assessment*	Lehmann, A., Bach, V., Finkbeiner, M.
2014	Int J Life Cycle Assess	*The European Commission Organisation Environmental Footprint method: comparison with other methods, and rationales for key requirements*	Pelletier, N., Allacker, K., Pant, R., Manfredi, S.
2014	Proceedings 9th Int. Conference on LCA in the Agri-Food Sector	*The EU Organisation Environmental Footprint applied to the Retail sector*	Pedrazzini, S., Humbert, S., Dubois, C., Adams, A., Grossmith, A., Léglise, P., (. . .) Wildenberg, M.

Table 2. Scientific articles related to the Organizational Life Cycle Assessment (O-LCA).

Year	Source	Title	Authors
2019	Int J Life Cycle Assess	*The implementation of organizational LCA to internally manage the environmental impacts of a broad product portfolio: an example for a cosmetics, fragrances, and toiletry provider*	Moreira de Camargo, A., Forin, S., Macedo, K., Finkbeiner, M., Martínez-Blanco, J.
2018	Int J Life Cycle Assess	*Hybrid approach for the evaluation of organizational indirect impacts (AVOID): combining product-related, process-based, and monetary-based methods*	Finogenova, N., Bach, V., Berger, M., Finkbeiner, M.
2018	Int J Life Cycle Assess	*Facts and figures from road testing the guidance on organizational life cycle assessment*	Forin, S., Martínez-Blanco, J., Finkbeiner, M.
2018	Procedia CIRP	*Organizational Life Cycle Assessment: the introduction of the production allocation burden*	Manzardo, A., Loss, A., Niero, M., Vianello, C., Scipioni, A.
2018	J Clean Prod	*Definition and application of activity portfolio and contro/influence approaches in organizational life cycle assessment*	Manzardo, A., Loss, A., Jingzheng, R., Zuliani, F., Scipioni, A.
2018	Int J Life Cycle Assess	*Launch of a new report: Road testing organizational life cycle assessment around the world: applications, experiences and lessons learned*	Martínez-Blanco, J., Forin, S., Finkbeiner, M.
2017	Int J Life Cycle Assess	*Organizational life cycle assessment: suitability for higher education institutions with environmental management systems*	Lo-Iacono-Ferreira, V. G., Torregrosa-López, J. I., Capuz-Rizo, S. F.
2016	Int J Life Cycle Assess	*ONE TWO WE—life cycle management in canteens togetherwith suppliers, customers and guests*	Jungbluth, N., Keller, R., König, A.
2016	J Clean Prod	*Enhancing environmental management in the textile sector: An Organisational-Life Cycle Assessment approach*	Resta, B., Gaiardelli, P., Pinto, R., Dotti, S.
2015(a)	Journal of Life Cycle Assessment, Japan	*Half-way Point in the Flagship Project "LCA of Organizations" by UNEP/SETAC Life Cycle Initiative*	Martínez-Blanco, J., Inaba, A., Finkbeiner, M.
2015(b)	Int J Life Cycle Assess	*Scoping organizational LCA—challenges and solutions*	Martínez-Blanco, J., Inaba, A., Finkbeiner, M.
2015(c)	Int J Life Cycle Assess	*Organizational LCA: the new member of the LCA family—introducing the UNEP/SETAC Life Cycle Initiative guidance document*	Martínez-Blanco, J., Inaba, A., Quiros, A., Valdivia, S., Milà-i-Canals, L., Finkbeiner, M.

4.3. Main Authors and Scientific Journals

The main authors who contributed to the development of the O-LCA methodology are undoubtedly J. Martínez-Blanco and M. Finkbeiner, who have currently published nine and six articles, respectively, five of which are in collaboration. Regarding the OEF, there are no recurring authors.

The scientific journal that to date paid the most attention to the two methodologies is the International Journal of Life Cycle Assessment (10 publications, 50% of the scientific articles). This has been considered by far the most appropriate scientific platform for the diffusion of O-LCA studies. Following are the Journal of Cleaner Production (3 publications) and other journals with a single contribution (Figure 1).

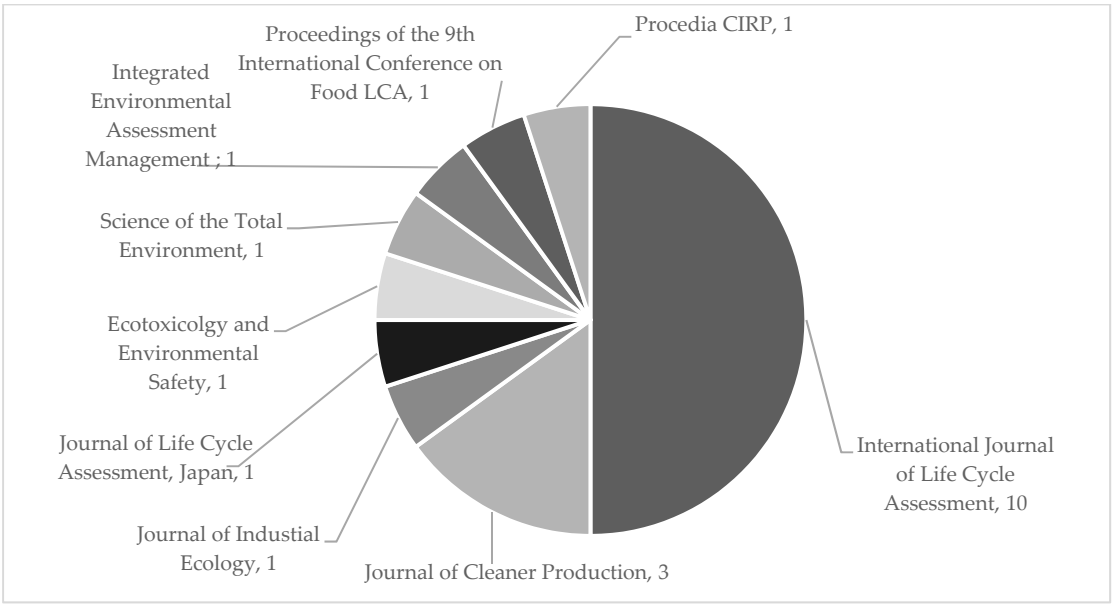

Figure 1. Number of publications on scientific journals.

4.4. Recurring Terms and Concepts and Their Relations

As mentioned above, the search for contributions was carried out by searching for the most representative concepts and acronyms of the methodologies. Once the articles with focus on O-LCA and OEF were identified, we searched for the keywords used and many times these keywords were repeated, how they were associated with each other, and how they were analyzed, all of which denotes a close connection between two arguments. Such network analysis allows researchers to highlight possible trends in progress within the field, the intrinsic complexity of the object of study or terminological questions that can be addressed to simplify and make the dissemination of knowledge more effective. The graph showed in Figure 2 was obtained through the construction of a two-mode matrix articles (rows) x key concept (columns), by which the authors classified all the references emerged from the literature review. Such a matrix has been processed by Ucinet (Borgatti et al. 2002) software.

Larger size nodes represent trend-topics and describe the most recurrent key concepts in the literature. Lines size represent the frequency with which two concepts appear together. The nodes placed at the center of the graph represent the key concepts at the center of debate on OEF and O-LCA fields are capable of linking more arguments among themselves. Moving away from the central part of the graph, increasingly "niche concepts" can be found. Furthermore, colors were associated to some nodes in order to highlight the presence of fairly homogeneous sub-groups (blue and red respectively indicate the two O-LCA and OEF methodologies; yellow indicates official documents published on the two methodologies; green indicates concepts that recall methodological aspects; in pink some advantages emerged; light blue refers to product-based assessment methods).

Specifically, by observing the network in Figure 2, it is possible to extrapolate certain evidences. As a confirmation of what has been stated previously, it can be noted that the O-LCA is investigated more often than the OEF. Next, the concept of LCA is frequently appointed as a term of comparison with the environmental footprint. Furthermore, the articles published so far have often referred to supply chain and specific sectoral, which represent the most significant thematic trends. Equally recurrent are the references to technical norms and procedures. Only a few articles refer to potential results and benefits, but this is consistent with the relatively recent development of those methodologies. Finally, it seems that studies on O-LCA (frequent relationships with supply chain, sector, case study, environmental management) have a more applicative approach than those on OEF, which instead are more oriented towards methodological aspects (frequent relations with PEF, ISO/TS 14072).

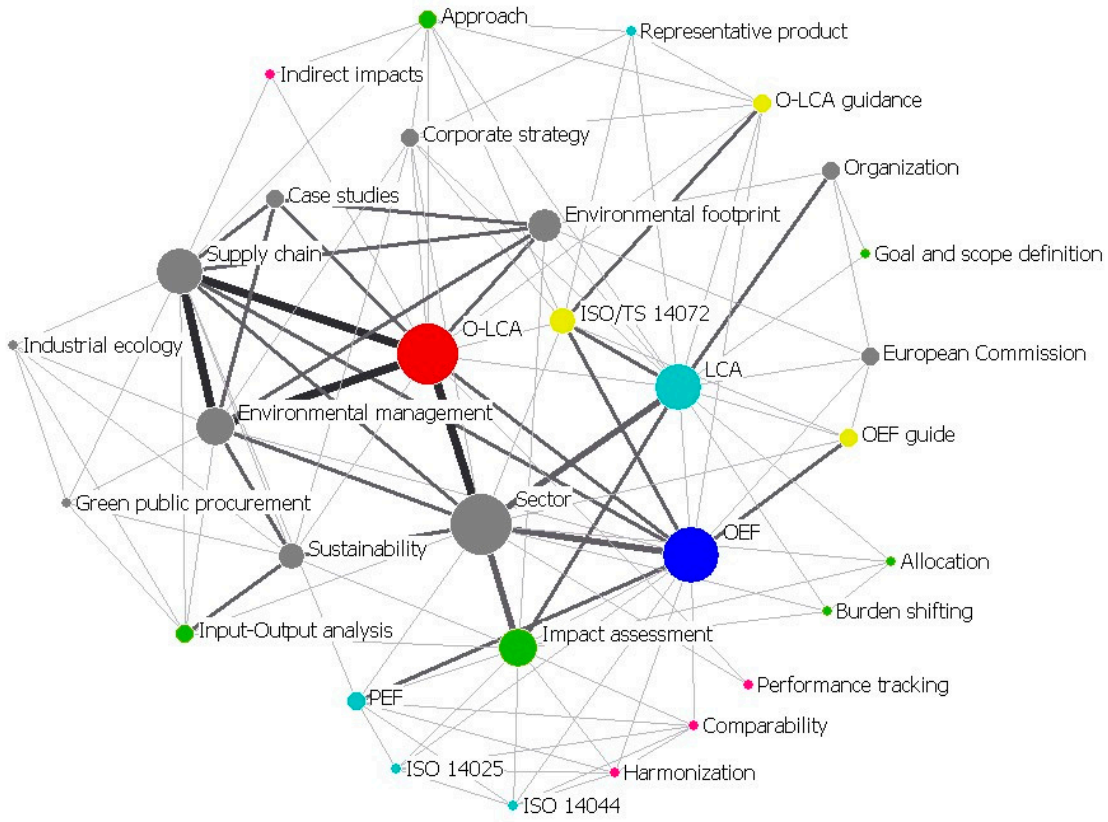

Figure 2. Visualization of the keywords network. (Data source: Scopus database).

4.5. Relevant Issues

As regards the aspects covered by the scientific articles published so far, the analysis carried out shows that most of them present analyses of case studies, and are, therefore, more focused on practical aspects (10). Others present mainly theoretical-methodological contents (7), focusing on the innovations introduced by OEF and O-LCA or by making comparisons between the two methodologies. The remaining ones balance theoretical-methodological and practical aspects (3). No review studies were found. In order to provide a more detailed overview of the topics covered by the various articles examined, we used the keywords and a content analysis to define a set of five key themes (Definitions; Methodology; Advantages; Comparison with other methods; Future Steps) and related specific topics covered, by which the articles have been classified and compared. The results of this step of analysis are illustrated in Tables 3 and 4.

Table 3. Emerging concepts from scientific articles on the OEF methodology.

	Authors (Year) / **Concepts**	Lehmann et al. (2015)	Martinez et al. (2018a)	Martinez et al. (2018b)	Neppach et al. (2017)	Pedrazzani et al. (2018)	Pedrazzini et al. (2014)	Pelletier et al. (2014)	Six et al. (2017)
Methodology	Life cycle approach	●		●	●	●	●	●	●
	Multi-criteria approach	●	●	●	●	●	●	●	
	Main criteria						●	●	
	Comparability over flexibility	●						●	
	Reproducibility				●	●	●	●	
	Cut-off	●			●			●	
	Recycling/EoL formula	●						●	●
	OEF - SMEs							●	●
	Use of input-output analysis		●	●					
Advantages	Track environmental performance			●	●			●	
	Harmonized method	●				●			●
	Holistic/integrated point of view		●		●				
Comparison with other methods	OEF - O-LCA				●				
	OEF - GHG protocol				●			●	
	OEF - Other methods			●				●	
Future steps	Challenges	●		●			●	●	●

Table 4. Emerging concepts from scientific articles on the O-LCA methodology.

	Authors (Year) / *Concepts*	Moreira de Camargo et al. (2019)	Finogenova et al. (2018)	Forin et al. (2018)	Jungbluth et al. (2016)	Lo-Iacono-Ferreira et al. (2017)	Manzardo et al. (2018a)	Manzardo et al. (2018b)	Martínez-Blanco et al. (2018)	Martínez-Blanco et al. (2015a)	Martínez-Blanco et al. (2015b)	Martínez-Blanco et al. (2015c)	Resta et al. (2016)
Definition and name	Definition	●		●			●			●	●	●	●
	Name									●	●	●	
Methodology	Life cycle approach	●	●	●		●		●	●	●	●	●	●
	Multi-criteria approach	●	●	●	●	●		●		●	●	●	●
	Organizational approach	●		●						●	●	●	
	Time references	●	●	●		●					●		
	Pathways	●		●		●						●	
	Phases	●		●		●	●	●	●	●	●		●
	Consolidation method	●		●		●	●	●		●	●		
	Direct and indirect activities	●	●	●		●	●	●	●	●	●		●
	Reporting unit	●		●	●	●	●	●		●	●	●	●
	Activity portfolio						●						
	Off-setting									●	●		
	Omissions or simplifications	●				●							
	Comparisons between organizations	●				●	●			●	●	●	●
	O-LCA - SMEs		●	●						●		●	
	Service organizations					●			●		●		
Advantages	Benefits	●	●	●		●	●	●		●	●	●	●
	Support decision-making	●		●		●		●	●	●	●	●	●
	Track environmental performance	●	●	●		●	●	●	●	●	●	●	●
Comparison with/Mention of other methods	O-LCA - LCA	●	●	●		●	●	●		●	●	●	●
	O-LCA - SO-LCA						●	●	●				
	O-LCA - EMAS			●		●							
	O-LCA - OEF		●	●		●	●	●	●	●	●	●	●
	O-LCA - GHG protocol	●	●	●	●	●				●	●	●	
Future steps	Challenges	●	●	●		●	●	●	●				
	Implementation/Spread/Common	●	●	●		●		●	●	●		●	●
	Update			●					●				

As shown in Table 3, the scientific articles on OEF mainly focuses on: methodological aspects, advantages deriving from its implementation, comparisons with other methods, and future developments of the methodology. Almost all the works show that the methodology follows a life cycle and multi-criteria approach (reference is made to 14 predefined environmental impact categories). Another significant aspect that emerged from the analysis of the articles is the reproducibility of the OEF studies, ensured by the high rigidity of the principles and requirements provided by the guideline, identifying specific sector rules and limiting the arbitrariness of the methodological choices (e.g., cut-offs are not allowed). Therefore, the possibility of comparing the OEF studies is granted (instead, it is forbidden by the O-LCA methodology). With reference to the practical application of the methodology, in more than one article the use of multi-regional input-output analysis for the acquisition of data for the inventory phase was found. Unlike what was found in the articles regarding the O-LCA, very rarely are other methods mentioned. Finally, most of the contributions highlighted the main difficulties encountered in applying the OEF, proposing solutions for future implementations.

With regard to the O-LCA methodology, the topics that emerged refer mainly to methodological aspects, advantages deriving from implementation, and future developments of the methodology (see Table 4). The main issues addressed were: (i) the phases of the study (the same foreseen by the ISO 14044); (ii) the consolidation method; (iii) the classification of direct and indirect activities (upstream and downstream the organizational boundaries); (iv) the reporting unit (which represents the unit of analysis and is composed of two elements, namely reporting organization and reporting flow; (v) the time references (the performances of an organization, compared to those of a product, are more likely to experience modifications from one period to another, for example due to changes in the product portfolio); (vi) the comparison of studies relating to different organizations (not permitted by the methodology); (vii) the peculiarities of service organizations and the provision of specific paths for implementing the method (pathways); and (viii) the simplifications for small and medium-sized enterprises. The articles usually indicate the advantages deriving from the implementation of the O-LCA, such as support for decision-making, traceability of environmental performance, and identification of environmental hotspots. Many contributions highlighted the challenges encountered and suggested proposals for future improvements.

4.6. Case Studies

Several case studies were identified among the various articles published on OEF and O-LCA. The organizations involved belong to different sectors, are of different sizes, are both private and public entities and are located all over the world. Below two tables are presented, one for each methodology (Tables 5 and 6), which contain: authors, sources, year of publication, name of the organization and sector within which it operates.

Table 5. List of case studies carried out following the OEF methodology.

Author/Source	Organization	Industry
Neppach et al. (2017) *	Implenia Group	Construction
Six et al. (2017)	Colruyt Group	Food
Martinez et al. (2018a)	N.A.	Woodworking
Martinez et al. (2018b)	N.A.	Construction
Pedrazzani et al. (2018)	N.A.	Wastewater treatment

* The study was not implemented due to the limited time of the research and the lack of information; N.A.: Not Applicable.

About the practical development of the OEF methodology, it is possible to underline that for some researchers it has been useful to use the multi-regional input output (MRIO) analysis. Despite some limitations (such as potential inaccuracies due to sectoral and spatial aggregations or temporal discrepancy between the reference period of the MRIOs and the data collected), it has been possible to use the MRIO tables successfully in both the construction and wood sectors (Martinez et al. 2018a, 2018b).

Table 6. List of case studies carried out following the O-LCA methodology.

Author/Source	Organization	Industry
ISO (2014)	Group of hotels (example)	Hotel and restaurant
UNEP/SETAC (2015) Martínez-Blanco et al. (2016)	Accor	Hotel and restaurant
UNEP/SETAC (2015)	BASF	Chemicals
UNEP/SETAC (2015)	Colruyt Group	Food
UNEP/SETAC (2015)	Inghams	Food
UNEP/SETAC (2015)	KPMG	Consulting and revision
UNEP/SETAC (2015)	Mondelēz International	Food
UNEP/SETAC (2015) UNEP/SETAC (2017) Moreira de Camargo et al. (2019)	Natura Cosmeticos	Cosmetics, fragrances and personal care
UNEP/SETAC (2015)	Shiseido	Cosmetics and personal care
UNEP/SETAC (2015)	Storengy (GDF Suez)	Natural gas
UNEP/SETAC (2015) Martínez-Blanco et al. (2016)	Unilever	Personal care, home care and food
UNEP/SETAC (2015)	Volkswagen Group	Automotive
Jungbluth et al. (2016)	SV Group	Food
Manzardo et al. (2016) Manzardo et al. (2018b)	San Benedetto	Food and beverage
Resta et al. (2016)	Texco	Textile
Lo-Iacono-Ferreira et al. (2017)	Universidad Politecnica de Valencia	Academia
UNEP/SETAC (2017)	AKG Gazbeton	Construction materials
UNEP/SETAC (2017)	Azbil Corporation	Electric appliances
UNEP/SETAC (2017)	Banco de Mèxico	Central Bank
UNEP/SETAC (2017)	Daimler	Automotive
UNEP/SETAC (2017)	Demarchi Industrial Complex-BASF-UPH	Coatings
UNEP/SETAC (2017)	Faculty of Science and Technology	Academia
UNEP/SETAC (2017)	Foundation Emmaüs	Social and recycling NGO
UNEP/SETAC (2017)	Junk that Funk	Waste management
UNEP/SETAC (2017)	Maschio Gaspardo	Agricultural equipment
UNEP/SETAC (2017)	Thanakorn Vegetable Oil Products	Food
UNEP/SETAC (2017)	Tuzla Belediyesi	Municipality
Manzardo et al. (2018a)	N.A.	Construction
Finogenova et al. (2018)	Brose Fahrzeugteile	Automotive

N.A.: Not Applicable.

Among these contributions, it is interesting to highlight the proposal by Manzardo et al. (2018a) to use the concept of activity portfolio instead of product portfolio. In fact, referring to the activities is very useful for those organizations that deliver heterogeneous products (e.g., in the construction sector) which have limited capacity to track environmental performance over the years. This approach allows analyzing the activities that are transversal to the products of the organization and generally stable over time.

Lastly, from the results above it is possible to see that the number of case studies carried out by applying the O-LCA methodology is significantly higher than those dedicated to the OEF methodology. In part it is possible to explain the phenomenon by saying that most of the O-LCA application cases have been reported in two official documents prepared by UNEP and SETAC, which are "Guidance on Organizational Life Cycle Assessment" (2015) and above all, the "road testing organizational life cycle assessment around the world" (2017). Furthermore, it is possible that the choice is also dictated by the greater flexibility granted by the O-LCA.

In the following section, attention will be paid to the main differences between the two methodologies.

4.7. Main Differences between OEF and O-LCA

The results presented in this section derive from the comparison of the official documents dedicated to the two methodologies (European Commission 2013; ISO 2014; UNEP/SETAC 2015). Differences concern both terminological-definitional and also procedural-applicative aspects. In general, the OEF uses a very new terminology and is "communication driven", while the O-LCA uses terms mainly based on ISO 14040 and ISO 14044 and is not "communication driven". More specifically, differences can be highlighted for each phase of the study and are described hereafter.

-Goal and scope definition: (i) the unit of analysis is broken down into two elements which are, for the OEF, the organization (unit of analysis) and the product portfolio (type and amount of goods and/or services), and for the O-LCA, the reporting organization (composed of a description of the organization, consolidation method, and reference period) and the reporting flow (measure of the outputs) that together constitute the reporting unit; (ii) OEF considers only operational or financial control as consolidation methods, while O-LCA considers also the equity share; (iii) according to the OEF guide, the system boundaries shall include the organizational boundaries and the OEF boundaries; (iv) OEF does not allows cutoffs and any data gap shall be filled using the best available generic or extrapolated data provided that such data shall not account for more than 10% of the overall contribution to each impact category; (v) the OEF guidelines also contemplate the realization of OEFSRs, with the aim of increasing the harmonization, specificity, relevance, and reproducibility of the studies (Martínez-Blanco et al. 2016).

-Inventory: (i) a screening step is recommended by the OEF; (ii) OEF requires specific data for direct processes or activities and for indirect ones where appropriate, while O-LCA requires specific data for unit that contributes to the majority of the mass and energy flows, and are considered to have environmentally relevant inputs and outputs; (iii) OEF defines minimum data quality requirements; (iv) the allocation procedures are handled in a way similar to ISO 14044 by both methodologies but O-LCA do not consider system expansion; (v) O-LCA addresses reuse and recycling separately, providing general principle of avoiding allocation while OEF provides a recycling formula for the end of life.

-Impact assessment: (i) classification and characterization are mandatory, normalization is recommended by OEF and optional for O-LCA and weighting is optional for both; (ii) OEF provides a default set of 14 mid-point impact categories and models, while O-LCA establish that the selection of impact categories, category indicators, and characterization models shall be both justified and consistent with the goal and scope of the study.

-Interpretation: OEF considers the option to disclose to the public comparative assertions among organizations within the same sector and according to the OEFSRs, while O-LCA expressly prohibits this possibility. In the ISO/TS 14072 standard comparative claims are considered neither robust nor significant, mainly due to the absence of a consistent basis for making a comparison among organizations (UNEP/SETAC 2015). Even within the same sector, the size, location, product segment, vertical integration, financial transactions, and overall business model can be significantly different (Finkbeiner and König 2013).

5. Discussion

The analysis conducted have highlighted some specific features, as well as strengths and weaknesses of the two most significant methodologies for assessing the environmental impact of organizations based on a life cycle approach.

O-LCA and OEF are methodologies designed for organizations of all sizes, both public and private, that operate in any sector and that are located anywhere in the world. They aim to support the identification and quantification of environmental aspects within and beyond the gates of organizations and take into account all the partners in the value chain. Their application makes it possible to achieve multiple goals such as identifying environmental hotspots along the value chain, tracking environmental performance over time, supporting strategic decisions, and providing the information base for corporate sustainability reporting.

Both methods consist in the iterative succession of different phases, which are very similar, in particular, to the PEF and LCA. According to Finkbeiner and König (2013), most of the requirements (27 out of 31) foreseen by the ISO 14044 standard are substantially transferable from products to organizations. Both O-LCA and OEF refer to an environmental multi-impact approach, meaning that a comprehensive set of environmental issues relevant for the specific system are considered, and together they represent the potential impact profile for the organization's activities (UNEP/SETAC 2015).

As recognized by Martínez-Blanco et al. (2016), the presence of a unique approach generally presents some advantages, i.e., facilitates the harmonization of the methods and avoids their proliferation, reduces the costs for the organizations, increases the applicability, and communicates to the consumers in a credible manner. This is not currently the case for the impact assessment of organizations, fortunately, the discrepancies do not seem to be so numerous and significant as to generate applicability problems, but it is desirable that, if there are differences, they are well identified and valued and not limited to terminological or procedural nuances.

The presence of some weaknesses can be considered physiological for methods that have been in use for a few years, they will necessarily have to undergo a refinement process that will progressively eliminate some of these gaps. At present, the most significant aspects highlighted by the literature are the following:

i. the difficulty to categorize the organizational activities and to gather all the data necessary to conduct the analysis, since some activities to include within the system boundaries (in particular, indirect activities) are not usually considered by the respective methodologies with focus on the product. In several cases, due to lack of data or resources or when considered not significant, some of these activities were excluded from the analysis (Resta et al. 2016; Neppach et al. 2017; Six et al. 2017; UNEP/SETAC 2017; Forin et al. 2018; Manzardo et al. 2018b; Moreira de Camargo et al. 2019);
ii. the lack of necessary data on the LCA databases, both for the inventory phase and for the impact assessment, linked to the fact that some activities were not analyzed until the focus moved to the organizations. In fact, some road testers built additionally customized Excel-based calculation tools or regional database to carry out the inventory analysis and/or the impact assessment (Jungbluth et al. 2016; UNEP/SETAC 2017; Finogenova et al. 2018; Forin et al. 2018; Moreira de Camargo et al. 2019);
iii. the choice of best-selling or representative products, when using a bottom-up or hybrid approach to collect data, in the event that product variations are significant even within the same product family (Jungbluth et al. 2016; Finogenova et al. 2018; Moreira de Camargo et al. 2019).

The main strengths that have emerged are:

i. the methodologies allow to have a complete view of the system under investigation, to identify all the hotspots and with what priority to act on them. In turn, the complete vision of the organization allows to avoid burden shifting that can occur when analyzing only a part of the activities of an organization (Manzardo et al. 2016, 2018b);
ii. the methodologies lead to a closer collaboration with the other actors in the value chain, potentiating the relationships, the quantity and the quality of the data collected as well as the extent of environmental performance improvements (Jungbluth et al. 2016; Resta et al. 2016; Lo-Iacono-Ferreira et al. 2017; Neppach et al. 2017; Forin et al. 2018; Martinez et al. 2018a, 2018b);
iii. it is possible to benefit from previous experience with other environmental methods or tools (Lo-Iacono-Ferreira et al. 2017; UNEP/SETAC 2017; Forin et al. 2018; Moreira de Camargo et al. 2019).

6. Conclusions and Future Developments

The development of methodologies and tools for assessing the environmental impacts of organizations through life cycle approaches represents an important methodological and practical-operational advancement, both from the scientific and the applicative point of view. Moreover, it allows to overcome some intrinsic limits of the perspectives focused on products and processes, due to the possibility of including in the analysis activities that are usually neglected, since they can only be indirectly connected to the object of investigation (e.g., common activities and services, business travels, employee commuting). Moreover, a more organizational-centered perspective may amplify the internal and external relevance that assessment methodologies can have, both in terms of

stakeholders commitment (e.g., for workers and or supply chain actors) and also for reporting and communication requirements, that increasingly include data and information about the environmental performances of the entire organizations.

The study carried out highlighted how, despite the very recent development of the OEF and O-LCA methodologies, the scientific community has immediately recognized their importance, as well as the organizations themselves, which are often involved in the application of pilot tests and studies. The small amount of contributions that emerged makes still little significant bibliometric analysis, while the contents of the scientific articles published so far, ranging from terminological and defining aspects to methodological ones in the strict sense, are much more interesting. Equally important was the emphasis on highlighting the advantages and future developments of the methodologies and the comparison between them or with other approaches aimed at assessing the environmental performance of organizations.

For the future, it is expected that the spread of the methodology will continue to increase with the hope that it will become easier for organizations to collect data on indirect activities, perhaps thanks to a closer collaboration with other partners in the supply chain, and that the databases will be expanded with the information needed to carry out studies focused on organizations. The increasing attention paid to the issues of environmental sustainability and the many potentialities of the approaches here presented lead to assume that organizations will be more aware of the impacts that they generate and committed to their reduction, being able to identify the main hotspots and having the information to support decision-making.

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