The International Journal of Life Cycle Assessment
https://doi.org/10.1007/s11367-024-02291-0

LETTER TO THE EDITOR

Requirements for comparative life cycle assessment studies for single-use and reusable packaging and products: recommendation for decision and policy-makers

Dario Cottafava[1] · Gaia Brussa[2] · Giulia Cavenago[2] · Daniele Cespi[3] · Lucia Rigamonti[2] · Alba Bala[4] · Joana Beigbeder[5] · Paul Refalo[6] · Ilija Sazdovski[4]

Received: 20 December 2023 / Accepted: 18 February 2024

Life cycle assessments (LCAs) are sensitive snapshots of a products' environmental impact, and their findings depend on how they are framed and modelled. Variations in assumptions, functional unit or system boundaries can completely change results and undermine their applicability and final outcome. In the framework of the circular economy, particularly important assumptions for reusable and single-use packaging include the number of reuses, weight, sanitising method, transport logistics and any other aspect which may influence the use phase. In addition, these variables are not fixed over time and may be affected by future changes in product design, consumers' habits or the supply chain management. As a consequence, the impact of different packaging options is not immutable and could change. Therefore, while comparing reusable versus single-use packaging, there is an urgent need to clarify and integrate the methodological requirements necessary to guarantee the reliability of studies and allow for impartial comparability of results.

Indeed, while it is straightforward to compare two single-use products in cradle to grave boundaries, it is more complex for products used multiple times, where it is the business model configuration—not the product—which is evaluated. In such cases, rather than evaluating only one single scenario (e.g. 20 reuses and 50-km distribution distance for the reuse phase), sensitivity and scenario analyses should be used to determine the break-even point. This represents for example the minimum number of times that a reusable product must be used to be considered environmentally better (if at all) than an equivalent number of single-use products. Only these recursive analyses can provide a systemic and comprehensive view. Studies that compare single-use products with reusable options and do not include sensitivity/scenario analyses or break-even points lack robustness and reliability.

In this regard, we came across four recent LCA studies comparing single-use vs reusable packaging where these methodological requirements are only partially satisfied. Specifically, Fig. 1 shows a comparison of four LCA studies, favouring either single-use or reusable packaging, with respect to the criteria we propose as necessary to guarantee scientific robustness. Therefore, focusing on the recent debate in the European Union (EU) on the Packaging and Packaging Waste Regulation (PPWR), we are concerned as these, and similar studies, can influence MEPs' decisions setting the EU on a potentially unfavourable trajectory for decades to come. We urge that if LCA studies are used to

Communicated by Matthias Finkbeiner.

Dario Cottafava, Gaia Brussa and Giulia Cavenago contributed equally to the manuscript.

✉ Daniele Cespi
daniele.cespi2@unibo.it

✉ Lucia Rigamonti
lucia.rigamonti@polimi.it

[1] Department of Economics and Statistics "Cognetti de Martiis", University of Turin, Lungo Dora Siena, Campus Luigi Einaudi, 100A, 10153 Turin, TO, Italy

[2] Department of Civil and Environmental Engineering (DICA) - Environmental Section, Politecnico Di Milano, Piazza Leonardo da Vinci 32, 20133 Milan, Italy

[3] Department of Industrial Chemistry 'Toso Montanari', Alma Mater Studiorum - University of Bologna, Via Piero Gobetti 85, 40136 Bologna, Italy

[4] UNESCO Chair in Life Cycle and Climate Change ESCI-UPF, Passeig Pujades 1, 08003 Barcelona, Spain

[5] IPREM, IMT Mines Ales, Université de Pau Et Des Pays de L'Adour, CNRS, E2S UPPA Pau, France

[6] Department of Industrial and Manufacturing Engineering, Faculty of Engineering, University of Malta, Msida 2080, MSD, Malta

Published online: 11 March 2024

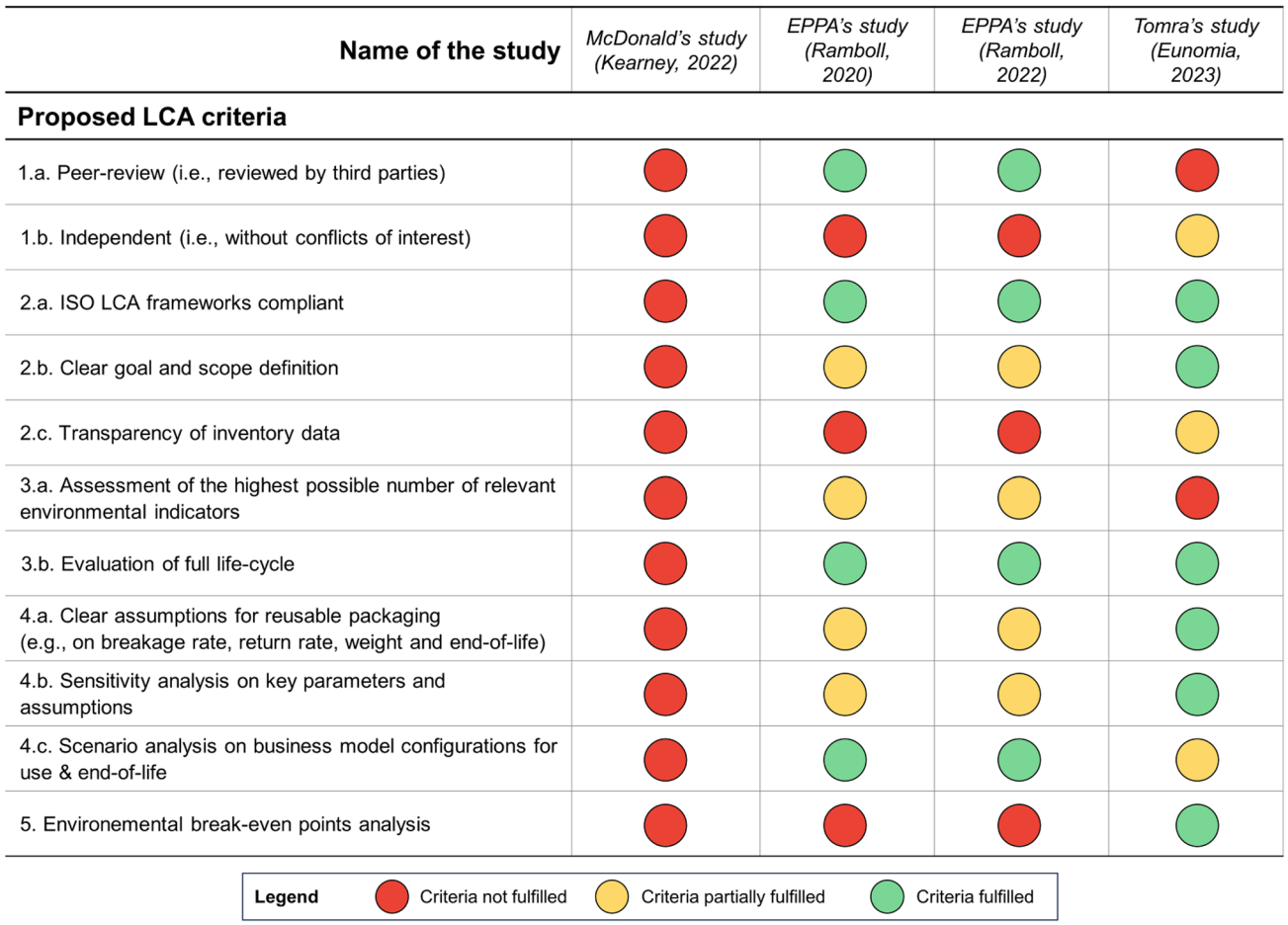

Fig. 1 Visual representation of the analysis of four life cycle assessment studies on single-use and reusable systems for dine-in and food take-away sector. The quality of the studies was assessed in light of the criteria and requirements for robust and methodologically sound analyses

make policy decisions, their methodology must be thoroughly scrutinised before publishing their results and conclusions. To guarantee its scientific robustness and objective impartiality, it is advised that an LCA study:

1. Is a peer-reviewed study, i.e. prior to public disclosure, the study should be reviewed by an independent third party or by an independently chaired review panel
2. Is an independent study, i.e. a study conducted by an independent third party without any conflict of interest with the beneficiaries of the study
3. Follows the ISO LCA framework and respects steps laid out in ISO 14040 and 14,044 standards. First, the goal and scope definition stage must precisely describe the product/s studied, the functional unit and corresponding reference flows, the scope of the study, the assumptions made for each life cycle stage, the expected audience and the methodology used to calculate impacts. Second, the inventory stage must describe and quantify the inputs and outputs involved in the life cycle of the system studied, by also declaring the data quality and uncertainty. Third, the LCA results should be presented at least in terms of characterised impact indicators. In fact, the impact assessment stage analyses the potential environmental impacts by converting the inventory data into specific impact indicators. This involves various steps, including mandatory selection, classification and characterization. Fourth, the results should be evaluated in the interpretation stage with the final aim being the formulation of objective recommendations to improve the environmental performance of the system under study.
4. Provides clear goal and scope definition. It is emphasised that access to the goal and scope definition (stage 1) is a non-negotiable prerequisite to validity
5. Ensures transparency of the inventory data. This is because even a small variation in the methodological parameters (stage 2) can significantly alter results
6. Assesses the highest possible number of relevant environmental indicators. This is possible by using a

multi-impact analysis method. Some examples are the EU Environmental Footprint (EF 3.0), the recognized method for the Commission Recommendation (EU) 2021/2279 that includes 16 midpoint impact categories (i.e. problem oriented), the ReCiPe 2016 or the IMPACT World+. The latter extends the analysis to 18 impact categories. Among those most used are climate change, resource depletion (water, fossil and mineral), impacts on land compartments (e.g. use and transformation), human toxicity (cancer and non-cancer) and others. Any exclusion of an impact category must be thoroughly justified

7. Evaluates the full life-cycle of the product reviewed, from cradle to grave. Both upstream (e.g. material production), core (use phase) and downstream impacts (e.g. recycling or incineration) must be included in the evaluation
8. Includes clear assumptions for reusable packaging on breakage rate, return (trip) rate, weight of the packaging, capacity of the packaging product and end of life strategies (including recycling performance and quality of the recyclate) both for single-use and reusable packaging
9. Performs sensitivity analyses on key parameters and assumptions by disclosing the source of such data, if lower quality data on parameters have been used. The conclusion of these analyses should be included in the study, to ensure that the implications of using poor quality data are transparent
10. Considers scenario analyses on business model configurations for the use and end-of-life phases, alongside clear sensitivity and scenario analyses about, among other, sanitising methods, transport distance, or transport mode
11. Evaluates the environmental break-even points, by integrating static comparisons with dynamic ones which include the number of reuses

From Fig. 1, it immediately emerges that the analysed LCA studies exhibit varying degrees of criticality, i.e. they are lacking the fulfilment of the indicated criteria.

We highlight the current lack of an international standard which integrates the requirements of ISO 14040 and 14,044 with the most recent advancements in circular economy, specifically to points 4 and 5 of the proposed list of criteria in Fig. 1. The newest product category rules (PCRs) for the Environmental Product Declarations (EPD) of the International EPD System partially fill this gap but not completely. Indeed, although the current Packaging PCR 2019:13 asked to declare most of the necessary aspects to evaluate a reusable product, e.g. the maximum number of (re)uses and the generated impacts for a single use cycle—no indications are present on how to compare reusable and single-use products. In this sense, there is no dedicated international standard that regulates how to evaluate environmental impacts recursively (i.e. for reusable products or in terms of material flows). However, recently, the construction sector is moving in this direction by setting new rules for circular analyses by asking to fully integrate embodied impacts (from LCA analyses) with circularity indicators (e.g. the Material Circularity Indicators). Therefore, it is not anymore enough to simply declare the environmental impacts per phase or product (such as in the EPDs).

For these reasons, until new rules are introduced into the PCRs, we advise that future comparative studies between reusable and single-use products must fulfil the above listed requirements. Thus, we conclude that any report that assesses the environmental impacts without respecting the characteristics listed above lacks robustness, reliability and impartiality and would potentially mislead decision-makers. Therefore, caution should be exercised when considering its results and recommendations emanating from such reports or studies.

Declarations

Conflict of interest The authors declare no competing interests.

References

Eunomia (2023) Assessing climate impact: reusable systems vs. single-use takeaway packaging. Available online: https://circulareconomy.europa.eu/platform/en/knowledge/assessing-climate-impact-reusable-systems-vs-single-use-takeaway-packaging#msdynttrid=CqHGl72JP029E6usJwePTF-J8Lt0f-9omyelVn3KwZU

Kearney (2022) No silver bullet. Why a mix of solutions will achieve circularity in Europe's informal eating out (IEO) sector. Available online: https://www.kearney.com/industry/consumer-retail/article/-/insights/no-silver-bullet

Ramboll (2020) Comparative life cycle assessment (LCA) single-use and multiple-use dishes systems for in-store consumption in quick service restaurants. Available online: https://eppa-eu.org/wp-content/uploads/2023/06/LCA-In-Store-Sudy-Ramboll.pdf

Ramboll (2022) Comparative life cycle assessment (LCA) single-use and multiple-use tableware systems for take-away services in quick service restaurants. Available online: https://eppa-eu.org/wp-content/uploads/2023/05/news-40684-EPPA-ACV-emballages-vente-emporter.pdf