The Social Construction of Environmental Reality: An Analysis of Life Cycle Asses sment in the Food Industry

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DOI: 10.64370/YDVU1057

Abstract

This article offers a critical sociological-philosophical-communicological review of the Life Cycle Assessment (LCA) method in the context of the food industry. While LCA has been established as a standardized tool for quantifying environmental impacts, this study analyses it not merely as a technical method but as an epistemological construct that actively shapes societal understanding of sustainability. Drawing on the theory of social construction of reality, situated knowledge, and critical theory, the article explores how methodological choices within LCA (e.g., system boundary definition and indicator selection) are not neutral but reflect specific social and political priorities. The findings reveal that standardized LCA approaches often lead to epistemological reductionism by homogenizing complex ecological processes and neglecting local contexts and environmental justice issues. Furthermore, the article examines the instrumentalization of LCA in sustainability communication and green marketing, where quantitative data are frequently used to legitimize existing business models rather than to drive systemic change. The discussion emphasizes the need to transcend instrumental rationality and shift toward transdisciplinary and deliberative approaches. The article advocates for integrating Social Life Cycle Assessment (S-LCA) and broader Life Cycle Sustainability Assessment (LCSA) frameworks to address sustainability challenges in the food industry more holistically, incorporating social justice and cultural sensitivity.

Keywords: life cycle assessment (LCA); social construction of reality; situated knowledge; sustainability environmental communication; epistemology of ethics; sociology of responsibility

1. Introduction

In recent decades, sustainable development and environmental responsibility in the global economy, particularly in the food industry, have gained unprecedented significance. This stems from growing public awareness of anthropogenic environmental impacts and shifting consumer demands for more ecologically sustainable and ethically acceptable practices. As the environmental crisis raises fundamental questions about the limits of human activity within planetary boundaries (Rockström et al., 2009), measuring and understanding environmental impacts has become crucial for both the scientific community and policymakers.

The food industry is a key sector with substantial impacts on natural resource use, greenhouse gas emissions, water consumption, and biodiversity. Poore and Nemecek (2018), in their comprehensive meta-analysis, highlight the extreme variability of environmental impacts across different food products and production systems, underscoring the need for robust assessment tools. In this context, Life Cycle Assessment (LCA) has emerged as a standardized method for evaluating the environmental footprint of products, processes, and services.

LCA provides a holistic evaluation of impacts across all life cycle stages: from raw material extraction ("cradle"), through processing, distribution, and use, to final disposal ("grave") or reuse ("cradle-to-cradle"). By focusing on the entire life cycle, LCA reveals complex interconnections between economic, environmental, and increasingly social dimensions of food production. It identifies "hotspots"—phases or processes with the highest environmental impacts—where technological or procedural improvements can significantly reduce overall footprints.

However, this article posits that LCA is not a neutral technical tool for quantification. Instead, we analyze it as an epistemological instrument that transcends mere measurement, exposing deeper philosophical and sociological dimensions of environmental thought. LCA is an epistemological construct that actively shapes societal perceptions of environmental reality. This epistemological framework defines what counts as "environmental reality" in a given historical and social context.

Such perceptions are not necessarily reflections of objective conditions but are co-shaped by cultural, political, and economic factors, the diverse needs of stakeholders, and the ideological orientations of experts. For instance, the preferences of study commissioners or the interests of funders of specific technological solutions can influence methodological choices in LCA (e.g., system boundaries or allocation methods). Additionally, data limitations, methodological constraints, and insufficient funding for comprehensive studies further shape these perceptions (Finnveden et al., 2009).

Traditional environmental LCA (E-LCA) often falls short in capturing the full complexity of sustainable food systems. Quantitative data alone cannot fully explain the social consequences of food production and consumption. Thus, sustainability policymaking must account for how societal discourses and normative structures influence the definition of metrics and standards, requiring interdisciplinary approaches that integrate social perspectives into environmental assessments (Gugushvili & Otto, 2023).

The aim of this article is to conduct a critical sociological-philosophical-communicological review of LCA in the food industry. We focus on analysing its epistemological assumptions, conceptual boundaries, and societal implications, demonstrating how LCA co-shapes perceptions of nature and proposed solutions to environmental crises. Using concepts from the philosophy of science, environmental ethics, and social construction theory, we illuminate how scientific methods are not passive reflections of reality but active participants in its construction. The analysis specifically addresses issues of epistemological selectivity, impact standardization, and the political instrumentalization of sustainability communication in global frameworks like the European Sustainable Products Initiative.

2. Methodology

This article is designed as a critical theoretical review. As the goal is not an empirical case study but a meta-analysis of LCA's epistemological foundations and societal implications, the methodological approach combines discourse analysis, philosophical reflection, and synthesis of existing literature at the intersection of environmental studies, sociology of science, philosophy, and communication studies.

The methodology is grounded in a critical analysis of LCA through the lens of social constructivism and related theories. This approach allows us to examine how scientific procedures like LCA are embedded in broader societal processes of "reality" construction.

The critical review was conducted through literature review, discourse analysis, and theoretical synthesis. A systematic review of scientific literature on LCA's methodological challenges in agri-food systems (e.g., Finnveden et al., 2009; Poore & Nemecek, 2018) was paired with critical scholarship from the sociology of science and environmental humanities on the quantification and standardization of environmental problems. Discourse analysis was employed to examine how LCA is used and communicated in scientific, political (e.g., the European Sustainable Products Initiative), and market (green marketing) discourses. We investigated how certain metrics (e.g., carbon footprint) become dominant and how this shapes "environmental truth." Theoretical synthesis integrates findings from the literature review and discourse analysis within the proposed framework, identifying patterns of epistemological selectivity, reductionism, and instrumentalization in LCA.

For result interpretation, interdisciplinary insights were applied, including contemporary practices like digital technologies for data accuracy (Obrecht et al., 2024b; Popowicz et al., 2025), while critically assessing their limitations within existing social structures. This approach aims to move beyond numerical evaluation toward a more comprehensive understanding of sustainability that incorporates social and cultural factors.

2.1. Social construction of reality as an analytical tool

The core theoretical framework derives from Berger and Luckmann (1966), who, in The Social Construction of Reality, argued that our understanding of the world results from ongoing social interactions, linguistic practices, and historical contexts. Reality is not a mere reflection of objective facts but the outcome of complex processes where it is negotiated, institutionalized, and reinforced. What we accept as "truth" is a product of social negotiation.

Traditional scientific approaches, often implicitly anchored in scientific realism (Bhaskar, 2008; Hacking, 2000), assume the existence of an objective, independent reality discoverable through empirical research. Social constructivism, however, emphasizes that even scientific "facts" (e.g., environmental impact measurements) are products of specific social histories, values, and institutions (Latour, 2004). In its strong form, constructivism posits that societal perception creates social reality as much as it reflects it. Meaning is assigned to objects and phenomena through human interaction with the world, mediated by cultural mechanisms like socialization (Jussim, 1991).

In this article, social construction theory is applied to analyse LCA. While LCA appears as an objective measure of environmental impacts, we treat it as a process involving the selection of categories, frameworks, and standards. These choices are non-neutral and influence how environmental problems are understood.

Language plays a key role. As Searle (1995) notes, social reality is built through linguistic practices that create and reinforce "social facts." Language is not just a communication tool but a medium for constructing reality. In LCA, this entails examining terminology (e.g., "carbon footprint," "ecosystem damage") that is not merely descriptive but also normative.

2.2. Situated knowledge and epistemological reflexivity

A second key methodological concept is "situated knowledge" (Haraway, 1988), which challenges the idea of complete objectivity and neutral, universal knowledge. Haraway (1988) stresses that all knowledge emerges from specific contexts, perspectives, and power positions. The analytical tools drawn from this concept include partial perspective and critical reflexivity.

Partial perspective acknowledges that all observers and researchers are "situated" within cultural, social, and historical frameworks. Our perception of reality is always constrained by our experiences and societal positions. For LCA, this means methodological, and data choices are influenced by the interests of researchers, study commissioners, or dominant scientific paradigms.

Critical reflexivity underscores the need for science to become self-reflective. Researchers should not only collect data but also critically examine how data are obtained, the assumptions behind methods, and how social, political, and economic interests shape scientific understanding. Foucault (1975) extends this perspective by showing how scientific and technical discourses are part of broader power mechanisms. Measurement and categorization are not just technical procedures but are heavily influenced by societal and institutional expectations, producing what we call "truth." LCA, as a method, operates within this tension: it functions as a "disciplinary apparatus" (Foucault, 1975) that selectively defines system boundaries and what counts as an "environmental cost" (Hornborg, 2019).

By integrating these concepts, we aim to move beyond traditional reductionism and introduce greater epistemological openness into measurement practices. This involves analysing how societal discourses are shaped through measurement procedures (Weder, Podnar & Golob, 2025).

2.3. Defining the subject of analysis: LCA in the food industry

The subject of analysis is the LCA method as defined by international standards (ISO 14040 and 14044) (ISO, 2006a, 2006b), with a focus on its application in the food industry. LCA is a comprehensive approach to assessing the environmental impacts of products throughout their life cycle, typically involving four phases:

Goal and Scope Definition: Determines the purpose, system boundaries, and functional unit, directly influencing the validity and interpretation of results.

Life Cycle Inventory (LCI): Collects data on inputs (materials, energy) and outputs (emissions, waste). Data gaps can distort outcomes.

Life Cycle Impact Assessment (LCIA): Evaluates environmental effects (e.g., climate change, acidification, toxicity).

Interpretation: Analyses findings and formulates improvement recommendations.

Our analysis examines how the theoretical concepts of social construction and situated knowledge manifest in these standardized phases, particularly in complex systems like the food industry, chosen for its significant environmental footprint and socio-economic linkages.

3. Results

The critical analysis reveals that LCA, despite its apparent objectivity, functions as a powerful mechanism for constructing environmental reality. Findings are structured around four themes: epistemological selectivity in defining LCA, reductionism from quantifying complex systems, social/ethical implications, and LCA's instrumentalization in communication and policy.

3.1. Epistemological selectivity and the construction of environmental reality

Defining "environmental truth" is not just technical but a socially constructed process. LCA participates in this through its methodological phases, especially goal and scope definition.

3.1.1. The politics of system boundary demarcation

The LCA methodology mandates explicit delineation of system boundaries (ISO, 2006a). However, this demarcation is not merely a methodological formality but a political and ethical act (Giampietro & Mayumi, 2009). Within the food industry, such boundaries are frequently circumscribed to align with vested interests. Consider, for instance, LCAs of intensive European livestock systems: the environmental burdens linked to feed production—deforestation, pesticide application, and land dispossession in South America—are routinely externalized through the use of averaged datasets or truncated system scopes. This epistemic selectivity facilitates the spatial dislocation of environmental costs, a phenomenon Martinez-Alier (2002) critiques as emblematic of "the environmentalism of the poor," wherein ecological degradation is displaced onto marginalized populations. By operationalizing such boundary work, LCA functions as a disciplinary apparatus (Foucault, 1975), rendering certain impacts "visible" (e.g., on-farm emissions) while relegating others (e.g., colonial land-use dynamics) to the realm of the "invisible" (Scott, 1998). Consequently, production practices are discursively legitimized as "sustainable" precisely through the strategic exclusion of their transnational externalities.

3.1.2. Functional units as value-laden constructs

The selection of functional units (FUs)—the quantifiable basis for comparative analysis—embeds normative presuppositions that privilege specific agro-industrial paradigms. Mass-based FUs (e.g., per kg of product) or energy-content metrics systematically favor hyper-efficient, industrialized systems optimized for yield maximization (e.g., input-intensive monocultures). This reductionist framing erases the multifunctionality of agrarian systems: biodiversity stewardship, cultural landscape preservation, and rural social cohesion are rendered illegible within the LCA's calculative logic. By collapsing the ontological complexity of food systems into

unidimensional efficiency metrics, LCA epistemically marginalizes holistic alternatives (e.g., agroecology), which may exhibit lower technical efficiency but superior socio-ecological resilience.

3.1.3. The epistemic violence of impact category selection

The prioritization of specific impact categories (e.g., global warming potential over soil microbiome degradation) is an enactment of power masquerading as technical necessity (Berger & Luckmann, 1966). The hegemony of carbon-centric metrics—a reflection of neoliberal environmental governance—systematically amplifies the epistemic authority of climate-centric frameworks while silencing competing narratives (e.g., toxics accumulation, agrarian knowledge erosion). This is not a neutral aggregation of "impacts" but a performative act that materializes certain realities (Latour, 2004): when LCA practitioners elect to quantify pesticide emissions via USEtox models (Rosenbaum et al., 2008) while omitting farmworker neurotoxicity studies, they co-produce an environmental reality where ecological harm is divisible from social harm.

3.2. The reductionism of quantification and homogenization of complexity

LCA is predicated on the assumption that nature can be measured and human impacts quantified. While quantification enables comparative analysis, this process risks oversimplification and the loss of essential contextual information.

3.2.1. Homogenization through indicators

The use of aggregated indicators—such as CO_2-equivalents for global warming potential—homogenizes the complexity of natural processes. Gases with distinct lifespans and ecological effects are reduced to a unified metric. Though methodologically expedient, this epistemic reductionism (Hornborg, 2001) collapses intricate interactions between agricultural practices, local ecosystems, and climatic patterns into singular numerical values.

For instance, livestock-to-crop comparisons based on carbon footprints often disregard pastoralism's role in biodiversity conservation or soil carbon sequestration. LCA may thus yield environmentally contradictory outcomes: a system optimized for carbon efficiency through intensification may simultaneously accelerate biodiversity loss or water depletion (Tilman et al., 2002), raising questions about its true sustainability.

3.2.2. Methodological uncertainties and modelling limitations

Impact characterization standards – particularly for complex categories such as biodiversity and land use – remain inadequately harmonized, undermining cross-study comparability (Hauschild et al., 2013), and reflecting what Robert Bullard (2005) identifies as "methodological environmental racism" in quantitative assessments. These

gaps systematically disadvantage marginalized communities, while privileging industry-friendly metrics. The case of Bayer-Monsanto's influence on pesticide impact modelling exemplifies this dynamic: their 2018 lobbying successfully narrowed the EU's LCA toxicity criteria to exclude endocrine disruptors (Corporate Europe Observatory, 2023).

The assessment of chemical toxicity (e.g., agricultural pesticides) exemplifies this epistemic fragility, and manifests what Beder (2006) terms "scientific mercenaryism". Beder analyses how corporations fund or control scientific studies to shape public opinion and policy in their favour. The term 'scientific mercenaryism' refers to the exploitation of science for commercial interests, where researchers or institutions act as 'mercenaries' for industry rather than providing independent evidence. She describes examples in the context of industries (e.g., tobacco, chemical) that manipulate data on health or environmental risks. Beder (2006) critiques this as a form of institutionalized bias, where science becomes a tool for corporate agendas rather than public good.

Models like USEtox (Rosenbaum et al., 2008), employed to quantify toxic impacts, rely on cascading assumptions about substance fate in ecosystems, exposure pathways, and dose-response relationships. Such assumptions carry inherent and substantial uncertainties. When LCA results are presented as definitive numerical outputs without transparent uncertainty analysis, they generate a fallacious impression of precision.

These practices generate "tunnel vision epistemologies" (Bammer, 2020) that violate the deliberative democratic principles. When Bayer-Monsanto's manipulated models are uncritically adopted in EU policy, they institutionalize what Jasanoff (2007, p. 33) calls "serviceable truths" – knowledge claims designed for regulatory convenience rather than ecological integrity. This epistemic violence becomes particularly acute when assessing Global South contexts, where the same models dismiss agroforestry systems as "unquantifiable".

Crucially, LCA's quantification practices are never merely technical exercises but interpretive acts of world-making. The method's outputs do not mirror "objective facts" but rather modelled representations of reality, contingent upon epistemic choices (e.g., selection of characterization factors), system boundaries, or value-laden normalization of incommensurable impacts. This epistemological tension mirrors Latour's (2004) paradox: the very tools meant to reveal environmental impacts actively shape what becomes legible as "impact."

3.3. Social and ethical implications: the neglect of justice

One of the most glaring shortcomings of conventional environmental LCA is its systematic neglect of the social and ethical dimensions of sustainability. Sustainability is not merely a question of environmental efficiency but also of social justice and equity (Sen, 2009).

3.3.1. Environmental justice and inequality

LCA often overlooks issues of environmental justice (Schlosberg, 2007), which concern the unequal distribution of environmental burdens and benefits among different social groups. The analysis focuses on aggregate impacts rather than on who bears them. In the food industry, these burdens frequently fall on agricultural workers exposed to pesticides, local communities suffering from water scarcity due to intensive irrigation, or communities in the Global South losing land to export crop production (Pulido, 2000).

By quantifying impacts while disregarding social consequences (e.g., effects on labour conditions, community health, food sovereignty), LCA neglects crucial ethical dimensions (Plumwood, 1993). A product may be deemed environmentally superior while its production remains socially unsustainable.

3.3.2. Situated knowledge and the exclusion of local perspectives

As a form of situated knowledge (Haraway, 1988), LCA often reflects the perspectives and values of those who develop and apply the method—primarily scientists and corporations from the Global North. This risks "epistemic colonialism" (Escobar, 2008), where the Global North defines sustainability metrics and norms that actors in the Global South must implement, regardless of local contexts and knowledge. This reinforces a neocolonial logic of environmental rationality that marginalizes alternative ways of understanding human-nature relationships (Shiva, 1989). Local knowledge and participatory methods that could broaden the interpretation of results are frequently excluded from standardized LCA procedures.

3.4. The instrumentalization of LCA in communication and policy

LCA is increasingly used as a basis for sustainability communication, green marketing, and environmental policymaking. However, findings reveal that this application is not without pitfalls.

3.4.1. LCA in green marketing and corporate legitimization

In the food industry, companies use LCA results to obtain eco-labels and communicate their sustainability commitments. Yet, analysis shows that LCA often becomes part of corporate "disciplinary self-regulation" (Bauman, 2007). Communication based on LCA tends to legitimize brands rather than drive systemic transformation in production.

Emphasizing specific indicators (e.g., reduced carbon footprint of a particular packaging) can divert attention from more problematic aspects of the entire value chain. As Golob, Podnar, and Žabkar (2023) caution, corporate sustainability communication often obscures systemic issues and shifts responsibility from institutional structures to individual consumer choices. Thus, LCA serves as a rhetorical tool that creates an impression of scientific rigor while potentially masking real sustainability challenges.

3.4.2. LCA in regulatory frameworks

The European Commission, under its Sustainable Products Initiative and Green Deal, promotes standardized methodologies like the Product Environmental Footprint (PEF), based on LCA (Busch, Ferrarini & van den Hurk, 2021). While these initiatives aim to enhance transparency and advance the circular economy, analysis shows that they largely operate within market-technological rationality. They focus on optimizing the existing system rather than addressing systemic transformation. Even in green and digital transition efforts, as Obrecht, Drašler, and Ogrin (2024a) warn, fragmented approaches persist, failing to holistically capture the systemic dimensions of sustainability. Standardization, though necessary for comparability, may stifle innovation and adaptation to local contexts.

4. Discussion

The findings of this analysis raise fundamental questions about the role of scientific methods like LCA in shaping environmental policy, public discourse, and practices in the food industry. If we accept that LCA is a socially constructed tool embedded in specific epistemological and institutional contexts, we must critically assess its presumed objectivity and universality. The discussion focuses on the implications of these findings and possibilities for developing more holistic and reflexive approaches to sustainability assessment.

4.1. Epistemological assumptions and the discursive nature of LCA

Results indicate that LCA is not a mere mirror of environmental reality but a lens that co-shapes it. The epistemological assumptions embedded in its methodology—choice of system boundaries, functional units, and impact categories—are not neutral (Finnveden et al., 2009). These choices determine which impacts become "visible" and significant, while others remain overlooked or marginalized. This construction process is crucial, as it defines the framework within which sustainability debates unfold.

The discursive nature of scientific methods demands that we interpret LCA as part of broader social practice. LCA is not just a measurement tool but also a narrative device. Quantification becomes a story about what we value and what we are willing to sacrifice. For instance, emphasizing carbon footprint as a primary metric creates a discourse that may favor certain technological solutions (e.g., high-tech intensive agriculture) over more ecologically integrated approaches whose benefits are harder to quantify within standard LCA frameworks.

This finding challenges the traditional divide between "objective" science and "subjective" interpretation. Scientific knowledge itself becomes part of meaning-making mechanisms (Latour, 2004). Thus, it is imperative that LCA applications explicitly articulate the assumptions and values underlying methodological choices. Transparency

is not just about data accessibility but also about disclosing epistemological and normative decisions. Without this, the demand for "scientific objectivity" risks becoming a rhetorical strategy to legitimize specific political or economic interests (Stirling, 2008).

4.2. The challenges of reductionism and the need for epistemic pluralism

The reductionism inherent in quantification, which homogenizes the complexity of ecological and social systems, is a central critique of LCA. Translating complex phenomena into simplified metrics loses contextual understanding. This is particularly problematic in the food industry, where local specificities (climate, soil, cultural practices, social structures) are key to sustainability.

The concept of situated knowledge (Haraway, 1988) offers an alternative to this universalizing tendency. Rather than seeking a singular, objective truth, it encourages the recognition of partial perspectives and the inclusion of diverse viewpoints. For LCA, this means moving beyond a purely techno-economic approach to incorporate local community perspectives, ethical norms, and social justice concerns.

Epistemic pluralism is needed. How can we integrate knowledge traditionally excluded from scientific arenas? Recent research highlights the importance of participatory methods and local knowledge (Lulovicova & Bouissou, 2024). Qualitative approaches, such as ethnographic studies and in-depth stakeholder interviews (farmers, workers, local residents), can reveal social dynamics and environmental impacts that quantitative LCA data alone cannot capture. This strengthens the integration of social knowledge into LCA, enabling a more comprehensive and equitable analysis.

4.3. Integrating social factors and environmental justice

Traditional LCA frequently ignores social consequences and questions of environmental justice (Schlosberg, 2007). Neglecting impacts on workers, local communities, or inequalities in resource access (Pulido, 2000) results in an incomplete sustainability assessment. Sustainable food systems must be not only environmentally sound but also socially just.

The development of Social Life Cycle Assessment (S-LCA) attempts to address this gap (UNEP, 2020). S-LCA incorporates social dimensions such as workers' rights, social equity, and community well-being. However, S-LCA also faces challenges in measuring subjective experiences and risks reducing social issues to a set of optimizable indicators without addressing structural inequalities.

A shift toward Life Cycle Sustainability Assessment (LCSA) is needed, integrating environmental (E-LCA), economic (LCC), and social (S-LCA) dimensions. Yet, this integration must not be merely additive. It requires a transdisciplinary approach

recognizing interconnections and conflicts between these dimensions. As Obrecht et al. (2024a) emphasize, systems thinking is crucial for understanding complex interactions in sustainability transitions.

In the food industry, this means sustainability assessments cannot ignore issues like food sovereignty, fair trade, or the impact of global supply chains on local economies. For example, a practice that reduces emissions while increasing farmers' dependence on multinational corporations for seeds and fertilizers cannot be labelled fully sustainable.

4.4. Political instrumentalization and sustainability communication

The use of LCA in marketing and policy reveals its role as a tool of power. LCA can serve as a mechanism to legitimize certain economic interests and reproduce the status quo. In green marketing, LCA results are often simplified into eco-labels, giving consumers a sense of responsible choice without demanding fundamental changes in production models.

This ties into broader challenges of sustainability communication. As Golob, Podnar, and Žabkar (2023) note, effective sustainability communication must go beyond quantification and information-sharing. It should open space for reflection, meaning making, and collaboration among diverse social actors. If communication relies uncritically on LCA results, it risks becoming a form of greenwashing that individualizes responsibility and obscures systemic problems.

Similarly, incorporating LCA into global regulatory frameworks, such as the EU's Sustainable Products Initiative (Busch et al., 2021), carries risks. Standardization dictated by the Global North may reproduce neocolonial patterns (Escobar, 2008; Shiva, 1989) by disregarding diverse epistemologies of nature and local contexts.

4.5. Beyond instrumental rationality: toward a deliberative approach

Critiques of LCA highlight the dominance of instrumental rationality (Habermas, 1984), where the focus is on means efficiency rather than reflecting on ends. Sustainability transformation in the food industry requires shifting from mere technical optimization to broader societal needs and ethical standards.

Environmental assessments should incorporate deliberative processes involving diverse stakeholders with differing perspectives and values (Kohn, 2013). This means actively engaging stakeholders in interpreting LCA results and shaping policies. Transparency and participation enhance the legitimacy of outcomes and foster inclusive dialogue among industry, policymakers, and consumers (Weder, Podnar & Golob, 2025).

Rather than presenting LCA results as absolute, researchers and decision-makers should clearly disclose assumptions, uncertainties, and exclusions shaping the

assessment. This would allow LCA to become a tool for learning and dialogue rather than merely reinforcing existing practices.

4.5.1. The normative role of science in sustainability policy

Science's role in sustainability policymaking is not merely descriptive but also normative. Scientific models and methods, like LCA, do not just reflect existing environmental conditions—they actively shape policy goals, priorities, and metrics. As Stirling (2008) warns, there is a risk of science "closing down" decision-making possibilities rather than "opening them up" when quantitative models are used as the basis for unambiguous policy decisions.

This normative power is especially pronounced when scientific findings underpin standardized policies and sustainability labelling. In this context, science must not act as an authoritative interpreter of reality but as a facilitator of pluralistic dialogue on values, priorities, and action pathways. This heightens its responsibility in co-creating just and inclusive sustainability transitions.

4.6. Limitations and recommendations for future research

This critical review highlights structural and epistemological limitations of LCA. However, the method continues to evolve.

A key practical limitation remains data availability. In the food industry, data on production practices, resource use, and emissions often vary by geography or culture, complicating accurate comparisons and reliability (Finnveden et al., 2009).

Moreover, LCA—especially in its standard environmental form—struggles to adequately capture socio-economic and cultural dimensions essential for holistic sustainability understanding. Result interpretation often simplifies complex interactions.

Future research should focus on:

Developing adaptive, context-sensitive LCA models: Models must better account for local environmental challenges, cultural practices, and social contexts rather than relying on standardized global assumptions.

Integrating qualitative and quantitative methods: Research should explore combining LCA data with qualitative insights from social sciences, including participatory stakeholder engagement.

Advanced technologies and transparency: Investigate the potential of AI and blockchain for improving data accuracy, traceability, and supply chain transparency (Obrecht et al., 2024b; Popowicz et al., 2025), while critically assessing their social implications.

Deepening S-LCA and LCSA analysis: Further methodological refinement and practical implementation of social and full life cycle sustainability assessments, with emphasis on addressing power and justice.

With these approaches, LCA can evolve into a more robust and socially relevant tool—one that serves not just technical optimization but genuine sustainability transformation.

5. Conclusion

This text has highlighted the intricate relationship between Life Cycle Assessment (LCA) methodology and the social construction of environmental reality in the food industry. The analysis demonstrates that LCA is not merely a neutral technical tool for quantifying environmental impacts but a powerful epistemological construct that actively shapes sustainability perceptions and decision-making.

Environmental reality, as perceived through the lens of scientific tools today, is not the result of linear accumulation of objective facts but a complex formation of discourses, institutional interests, and scientific representation (Latour, 2004). We have found that LCA's measurement procedures and methodological assumptions (system boundaries, functional units, indicator selection) are embedded in broader social, political, and cultural contexts. These choices are not neutral—they reflect dominant values and interests, potentially leading to epistemic reductionism and the marginalization of local perspectives and environmental justice concerns (Haraway, 1988; Martinez-Alier, 2002).

The quantification offered by LCA often homogenizes complexity and may yield solutions that are technically efficient within narrow parameters (e.g., carbon footprint) yet problematic from a holistic sustainability standpoint. Furthermore, we have illuminated how LCA is instrumentalized in sustainability communication and policy, frequently serving to legitimize the status quo rather than drive genuine transformation (Golob et al., 2023).

For a more comprehensive and just environmental future, it is essential to move beyond techno-scientific reductionism and instrumental rationality (Habermas, 1984). This article advocates for a transdisciplinary and deliberative approach—integrating social and ethical dimensions (via S-LCA and LCSA) while embracing diverse epistemologies and participatory methods.

The key question for the future is not merely improving LCA's measurement accuracy but fostering epistemic reflexivity within the scientific community and society at large. We must recognize that environmental science co-shapes reality. If we wish to advance truly sustainable and socially just transformation in the food industry, we must ensure that environmental truth is not merely a product of models and indicators but the result

of open, inclusive dialogue among science, society, and nature. LCA is an important tool, but it must be used with awareness of its limitations and social implications.

Note

All three authors are lead authors, as they had an equal leading role in the design and implementation of the research and the preparation of this article.

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