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SOCIETAL LCA

Social Life Cycle Assessment and Social Acceptance – Can they go hand in hand?

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Abstract

Purpose Social aspects are increasingly recognized as a standard component of sustainability. Social Life Cycle Assessment (S-LCA) is a technique to address this. The analysis of social acceptance points in a similar direction and is, among others, important to develop socially responsible products – but can they go hand in hand? This research explores the relationship between S-LCA and social acceptance in literature. The fundamentals of a framework are developed to beneficially combine S-LCA and social acceptance.

Methods To be able to examine the fundamentals, similarities and differences of S-LCA and social acceptance are outlined. This includes goals, definitions, and methodological aspects in addition to stakeholders, data, scope etc. Within a systematic literature review, publications addressing both S-LCA and the concept of social acceptance are identified and assigned to four groups. These different relationships include publications with either no statement or relationship, unclear relationship, the integration of social acceptance into S-LCA or vice versa.

Results and discussion The results indicate that the number of publications, predominantly from Europe, has increased in recent years. Publications frequently focus on the construction and wastewater sectors. The majority of assessed publications integrate social acceptance into S-LCA by establishing new impact categories, etc. however, only half of them are consistent with the S-LCA logic. An interpretation of social acceptance in alignment with S-LCA for this study, including methodological aspects, is presented. The discussion includes, among others, suggested approaches for further combinations of S-LCA and social acceptance, i.e. whether S-LCA can function as a communication tool and serve as a secondary data source for social acceptance analysis. It also includes the approach to combine data collection and to assess the discrepancy between their results.

Conclusions The findings of this research provide fundamentals for the development of frameworks for integrating S-LCA and social acceptance. This includes insights in general, as well as into both the practically implemented and theoretically conceivable ways of combining them. The identified practice within literature integrates social acceptance into S-LCA. The results conclude that S-LCA and social acceptance could go hand in hand. This is exceeded by discussions of additional approaches, which are to be tested in future case studies.

Keywords Social life cycle assessment · Social acceptance · Energy technologies · Review · Acceptance analysis

1 Introduction

The consideration of social aspects in the field of sustainability, next to environmental and economic aspects, becomes standard practice. The introduction of the directive on corporate sustainability due diligence of the European Union (2024) and the sustainability reporting standards by the European Commission (2023) – both including social aspects – are part of that development. Also in research programs by the European Commission, the role of social aspects is increasing, e.g., the requirement to integrate social

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sciences and humanities expertise, social sustainability and the assessment of social acceptance (European Commission 2025a, 2025b, 2025c; Morazzo 2024).

One technique to address these requirements of social sustainability is Social Life Cycle Assessment (S-LCA). It is designed to assess potential social impacts on different stakeholders along the whole life cycle of a product and is based on the established methodology Life Cycle Assessment (LCA) (EN ISO 14040 2009; EN ISO 14044 2006). Recently, ISO 14075 (2024) was published for S-LCA, releasing this methodology from its often labelled infancy. This standard defines social impacts as "beneficial or harmful consequences ensuing from the causal relationship between a process or activity related to the product system […] under study and aspects relating to human well-being of interested parties […]" (ISO 14075 2024).

S-LCA can stand alone or be part of a Life Cycle Sustainability Assessment (LCSA) (Klöpffer 2008). The results of an S-LCA address not only social responsibility by creating the chance to mitigate social risks by their identification, it can also help in decision making, development, and communication (ISO 14075 2024). It is not bound to a specific field and can be applied to all kinds of products, services or organizations (Social Organizational Life Cycle Assessment (SO-LCA)) and on different levels, e.g., materials, processes, products.

A topic gaining much attention is social acceptance. It can be understood as "a favourable or positive response (including attitude, intention, behaviour and – where appropriate – use) relating to a proposed or in situ technology or socio-technical system, by members of a given social unit (country or region, community or town and household, organization)" (Upham et al. 2015). It is significant when it comes to the implementation of new technologies (Assefa and Frostell 2007; Huijts et al. 2012; Wüstenhagen et al. 2007). Especially in the energy and mobility transition, research on social acceptance and the associated technologies receives much attention (Batel 2020; Batel et al. 2013; Ellis et al. 2023; Radtke 2025). By assessing the level of acceptance and the factors influencing it, the technology can be developed in a socially responsible manner and decisions can be guided to integrate public needs and avoid conflicts (L'Orange Seigo et al. 2014; Scovell 2022). If social acceptance is lacking, severe problems during the implementation of energy technologies might be faced (Batel 2020; Huijts et al. 2007, 2012; Wolsink 2018; Wüstenhagen et al. 2007).

Factors influencing social acceptance are often of psychological nature, e.g., perceived costs, benefits and risks, problem perception or trust (Emodi et al. 2021; Huijts et al. 2012; Upham et al. 2015; Witte 2021), but not solely, e.g., socio-demographic factors, location, prices, regulations and political aspects might have an influence as well (Batel 2020; Huijts et al. 2012; Witte 2021). While some researchers highlight the dependency of the factors on the specific context, e.g., the technology or the location (Ellis et al. 2023; Schmidt and Stybel 2025), others aim to build "overarching acceptance categories to address the multi-faceted acceptance factors" (Hübner et al. 2023), e.g., economic effects, attitudes (towards energy transition), impacts on the local community (residents and nature), trust (in local actors and planning process) and social norms (Hübner et al. 2023).

Some case studies implement S-LCA not only as a means to identify potential social impacts across the life cycle, but also to improve social acceptance (Furness et al. 2021; Mancini and Sala 2018; Zafar et al. 2024). However, evidence that S-LCA actually enhances social acceptance remains limited. Several publications directly or indirectly draw attention to the connection between the aspects that are part of S-LCA and social acceptance of products, e.g., through social sustainability as an overarching topic: "For a technical system to be deemed socially sustainable, it should at minimum enjoy wider social acceptance" (Assefa and Frostell 2007). Emodi et al. (2021) name benefits and risks in combination with social acceptance of new energy technologies. More straightforward statements come from Zafar et al. (2024) "[…] these opportunities are vital to advancing SLCA […] leading to the proceeding benefits of increased social acceptance […]." and Hannouf et al. (2025) "S-LCA can help to understand direct and indirect social impacts of the implementation and operations of the technology that can be controlled through technology features, identify the process needed to engage stakeholder groups in the development process, and improve social acceptance of technologies by stakeholder groups". In addition, Hadler et al. (2023) state that efforts to reduce climate change should always be paired with an analysis of social impacts, which can also increase acceptance of new technologies.

S-LCA and social acceptance point in similar directions. While S-LCA assesses the impact on stakeholders to identify a starting point for change, the analysis of social acceptance assesses the factors which are important for stakeholders as well as their acceptance. However, can they go hand in hand?

So far, the terms "social acceptance", "societal acceptance" or even "acceptance" and "acceptability" by itself, are not part of ISO 14075 (2024). They are neither stated in the UNEP (2020) guidelines nor in the corresponding methodological sheets (UNEP 2021), even though in the previous version of the guidelines, "social acceptability" was identified as a future research need (Benoit and Mazijn 2009). In other prevalent S-LCA literature, e.g., the Handbook for Product Social Impact Assessment (PSIA), social acceptance is not mentioned (Goedkoop et al. 2020).

Furthermore, S-LCA databases such as the Product Social Impact Life Cycle Assessment database (PSILCA) (Hamed et al. 2025) and the Social Hotspot database (SHDB) (Benoît Norris et al. 2018) do not consider it in their social topics.

The goal of this research study is to establish the fundamentals of a framework for the combined use of S-LCA and social acceptance. To address this, two research questions are raised:

- How is the relationship between S-LCA and social acceptance presented in literature?
- Which approaches could be used to create additional possible relationships between S-LCA and social acceptance beyond those identified in literature?

To answer the research questions and pursue the goal of this study, the work is divided into three levels. The first level has a descriptive character, aiming to establish a general understanding of S-LCA and social acceptance (Sect. 2.1). It elucidates the relationship between them, including the comparison of their definitions and terms, logical foundations as well as main characteristics with similarities and differences. In order to approach the existing views on their relationships, a systematic literature review (Sect. 2.2) is conducted, constituting the second level of this study. Herein the current state of the art for the combination of S-LCA and social acceptance is shown (Sect. 3) and further discussed (4.1). The third level of this study conceptualizes social acceptance in the context of S-LCA (4.2) and discusses additional approaches (4.3) to combine social acceptance and S-LCA. All three levels add to the fundamentals of developing a framework.

2 Methods

Before presenting the procedure for identifying relevant publications in Sect. 2.2, Sect. 2.1 provides more details on the main characteristics of S-LCA and social acceptance, including their logics, definitions, similarities, and differences.

2.1 Comparison of S-LCA and social acceptance

To lay the ground, in this first level of the study S-LCA and social acceptance are compared based on definition, goal, purpose, method, data, stakeholder, type and level as well as scope. An overview can be found in Table 1.

The American Psychology Association (APA), defines social acceptance as "the formal or informal admission of an individual into a group." and "the absence of social disapproval." (APA - American Psychological Association 2018). The former is related to the acceptance of humans, whereas the latter can be interpreted to include also objects. For approaching social acceptance of technologies, there is no one size fits all definition rather than different interpretations in dependance of the research field (Batel et al. 2013; Busse and Siebert 2018; Schumann and Hake 2015; Wüstenhagen et al. 2007).

Many publications are based on the understanding of Wüstenhagen et al. (2007), (e.g., (Huijts et al. 2012; Moesker et al. 2024; Rahman et al. 2019; Steller et al. 2024; Tsani et al. 2024; Weinand et al. 2022; Zaunbrecher et al. 2018). They have a focus on renewable energy innovation and divide social acceptance into three concepts with different stakeholders, i.e., socio-political acceptance of policies, market acceptance of consumers, investors and intra-firm as well as community acceptance. The latter addresses "siting decisions and renewable energy projects by local stakeholders, particularly residents and local authorities" (Wüstenhagen et al. 2007). The Technology Acceptance Framework (TAF) by Huijts et al. (2012) is often used as a basis for further research (e.g., by (Emmerich et al. 2020; L'Orange Seigo et al. 2014; Scovell 2022). They understand acceptance and consumer acceptance as divisions of public acceptance and relate them to energy technologies. Upham et al. (2015) also builds on Wüstenhagen et al. (2007) and has classified different types of energy technology acceptance by dividing social acceptance into general acceptance of technologies, community acceptance of infrastructure and market acceptance of the application object. This includes different levels, such as general, local and household, organization and end-user level.

In addition to the different attributes to acceptance (*social* acceptance, *consumer* acceptance etc.) the overall terminology differs widely. Some of these terms are used interchangeably, while others refer to distinct aspects. For example, Moesker et al. (2024) investigated the concepts of *acceptance* and *acceptability* in research of energy technologies and provide an overview of the different interpretations of the terms used within, as well as across, research fields. In addition, there is often neither a clean delineation of terms for *acceptance* and *perception* (Emmerich et al. 2018), nor for *legitimacy* and *attitudes* (Busse and Siebert 2018).

Over the years, the view on social acceptance and its purpose has changed. Batel (2020) divides the social acceptance of renewable energy technologies into three waves, starting from a normative understanding where opposition was explained by the "Not in my backyard" (NIMBY) phenomenon. The reasons for opposition of people were explained by ignorance and selfishness, and the expectation was to overcome this. This was followed by a second wave, where the NIMBY theory was criticized and local

Table 1 Comparative analysis: Logic of S-LCA, social acceptance and social acceptance analysis; S-LCIA - social life cycle impact assessment, S-LCPA - social life cycle performance assessment, SO-LCA – social organizational life cycle assessment

	S-LCA	Social acceptance	Social acceptance analysis
Definition	Technique, methodological framework (standardized) → assess social sustainability of products/services by identifying potential social impacts Social impacts: Positive or negative consequences on humans e.g., safe and healthy living conditions, local employment, corruption, access to material resources, etc.	Response (attitude, intention, behavior etc.) by humans → different definitions, e.g., favorable/positive response relating to a technology or socio-technical system	Different techniques and methods (not standardized) → assess social acceptance of humans e.g., by identifying factors influencing it Factors: Influencing social acceptance of humans positively or negatively e.g., perceived costs, benefits and risks, problem perception, trust, socio-demographic factors, location, prices, regulations and political aspects
	ISO 14075 2024	e.g. Busse and Siebert 2018; Upham et al. 2015; Wüstenhagen et al. 2007	e.g. Emodi et al. 2021; Huijts et al. 2012; Witte 2021
Goal	Amplify positive and mitigate negative effects to enhance human wellbeing over the long term		Depending on the analyst e.g., successful market introduction and/or integration of public needs into technology
	UNEP 2020		e.g. Batel 2020; Scovell 2022; Wüstenhagen et al. 2007
Purpose	Guide decision making and development; communication		Guide decision making and technology/policy development, e.g., to avoid conflicts, understand opposition etc.
	ISO 14075 2024		e.g. Batel 2020; Emmerich et al. 2020; Huijts 2018
Methods	Inventory analysis, S-LCIA, S-LCPA		Several, e.g., interviews, agent-based approaches, surveys etc. (not standardized)
	ISO 14075 2024		e.g. Schumann and Hake 2015; Witte 2021; Yetano Roche et al. 2010
Data	Primary, secondary, generic, site-specific, or combination	Primary, secondary	
	ISO 14075 2024	e.g. Emmerich et al. 2020; Emodi et al. 2021; Valencia Cotera et al. 2026	
Stakeholder	Workers, local community, society, consumers, value chain actors, etc.	General public, local authorities, residents, nature conservation organizations, users, end-users and consumers, investors	
	ISO 14075 2024; UNEP 2020	e.g. Wüstenhagen et al. 2007; Zöllner et al. 2012	
Types and levels	S-LCA (material, process, product, product system, …), SO-LCA (organization)	General acceptance, community acceptance, market acceptance on general, local, household, organization and end-user level	
	ISO 14075 2024; UNEP 2020	e.g. Upham et al. 2015; Wüstenhagen et al. 2007	
Scope	Assessing different life cycle stages	Mostly introduction and application stages	
	ISO 14075 2024	e.g. Shamsi 2025; Wüstenhagen et al. 2007	

opposition instead seen as "qualified resistance" (Batel 2020) with the goal to understand the opposition. Within the third wave it was acknowledged that discrimination, injustice and inequalities can go along with renewable energy technologies and therefore, it questioned if the opposition should be reduced (Batel 2020).

In comparison to social acceptance, the definition of S-LCA is more precise, as it is standardized (ISO 14075 2024). Nevertheless, the understanding of S-LCA itself and its methodological aspects, e.g., the selection of associated categories and indicators or the definition of performance reference points, differs among practitioners, and is not harmonized yet (Traverso and Mankaa 2025).

The goal of S-LCA is to identify „potential social impacts of a product system throughout its life cycle" where social impacts are "beneficial or harmful consequences ensuing from the causal relationship between a process or activity" (ISO 14075 2024). While S-LCA is a technique with a methodological framework, social acceptance constitutes an attitude or response (Upham et al. 2015) that only becomes a technique through its analysis.

The goal of analyzing social acceptance is not to increase or influence it, but primarily to know the acceptance level and gain insights into factors which influence the acceptance of people, with the purpose to include those into the decision-making of, e.g., communication, siting or design,

and the development of environmentally and socially sound technologies as well as strategies on a governmental level (Bechmann 1987; Emmerich et al. 2020; Huijts 2018). As addressed in the introduction, factors influencing social acceptance can have a variety of effects, such as facilitating or impeding social acceptance. A low level of social acceptance of technologies can foster failure with negative consequences, e.g., successful market introduction of technologies is often bound to their social acceptance (Scovell 2022; Witte 2021; Wüstenhagen et al. 2007). It is essential to distinguish social acceptance itself and the analysis of social acceptance.

S-LCA has a similar purpose as it can also help in product development and decision-making, as well as design, strategic planning, communication, marketing, identification of positive and negative impacts, assessing the social responsibility, and identifying and mitigating potential social risks (ISO 14075 2024).

The concepts of analyzing social acceptance are as versatile as its definitions. For example, Yetano Roche et al. (2010) distinguish different approaches to assess public attitudes for hydrogen and fuel cell vehicles including, e.g., general attitudinal surveys, risk perception studies and non-market economic valuation studies. Schumann and Hake (2015) states that in the research of carbon capture and storage (CCS) acceptance, a large range of empirical social research (quantitative and qualitative), experimental approaches and agent-based simulation are used. Also Witte (2021) lists several approaches to assess regional or product level CCS acceptance studies, e.g., the social license to operate (SLO), the stakeholder theory for management, the concept of procedural fairness and the theory of public engagement but also highlights that there are studies which do not use any specific methodologies.

The versatility of methods to analyze social acceptance makes it cumbersome to compare it against the S-LCA methodology. Therefore, common practice for analyzing was deviated and broken down from literature; tied under the heading social acceptance analysis: It usually starts with the identification of psychological and other factors that influence social acceptance (Emmerich et al. 2020; Emodi et al. 2021; Huijts et al. 2012; Scovell 2022; Valencia Cotera et al. 2026; Witte 2021), followed by some authors with an assessment of different stakeholders, either predefined (Huijts et al. 2012; Wüstenhagen et al. 2007) or from scratch (Emmerich et al. 2020; Emodi et al. 2021; Valencia Cotera et al. 2026). This is followed by data gathering for those factors and stakeholders from primary or secondary sources to be able to measure factors for social acceptance quantitatively or qualitatively (Emmerich et al. 2020; Emodi et al. 2021; Valencia Cotera et al. 2026).

This is similar to S-LCA, which comprises four phases: Definition of goal and scope, social life cycle inventory, social life cycle impact assessment and interpretation. There are three types of studies – the social life cycle analysis (Inventory analysis), social life cycle impact assessment (S-LCIA) using impact pathways and social life cycle performance assessment using reference scales (S-LCPA) (ISO 14075 2024). Predefined impact categories, subcategories and indicators from e.g., the UNEP (2020) guideline, databases such as PSILCA or SHDB (Benoît Norris et al. 2018) or other publications can be used. Another option, used in addition or solely, is the definition of new social topics, tailored to the needs of the individual study. Data can be generic, site-specific, primary, secondary or a combination of those (UNEP 2020).

When it comes to stakeholders in S-LCA, the assessment is commonly targeted, but not limited, to workers, the local community, society, consumers, children, value chain actors, smallholders and others (ISO 14075 2024; UNEP 2020). Definitions are partly provided, e.g., the UNEP (2020) guidelines refer to DIN ISO 26000 (2011), while Goedkoop et al. (2020) state their understanding within the publication. ISO 14075 (2024) does not contain definitions of stakeholders.

While analyzing social acceptance, workers are mostly not part of the assessment. More common is the involvement of the general public, local authorities, residents, nature conservation organization and consumers but also investors (Wüstenhagen et al. 2007; Zöllner et al. 2012). However, stakeholder definitions are scarce, which poses the challenge that the overlap of stakeholders in S-LCA and social acceptance cannot always be clearly separated or compared.

Another major difference is the scope of the assessment as S-LCA considers the whole life cycle or leastwise several life cycle stages, whereas the social acceptance of technologies more commonly concentrates on single parts, mostly the acceptance of its introduction and application respectively. In addition, the social acceptance of a technology as well as its social impacts are dynamic and can change over time. Within the field of social acceptance research, this topic is already being taken into account in existing studies (Ellis et al. 2023), whereas it is only starting to be implemented the case of S-LCA (Berridy-Segade et al. 2026; Ugaya et al. 2024).

With regard to S-LCA, it can be summarized that the underlying logic consists in identifying and assessing social impacts on humans, which may either be positive or negative (i.e. risks or opportunities). Damages such as those that may arise from the unsuccessful market introduction of a technology are not covered, even if insufficient social acceptance may be regarded as a contributing factor. Due to

the fact that such damages primarily constitute an economic rather than a social impact.

2.2 Systematic literature review

S-LCA and social acceptance analysis have been applied for many years. However, can they go hand in hand? To gain information about the relationship between S-LCA and social acceptance presented in literature, a systematic review was conducted in February 2025. This is part of the second level of this study. The publications will be divided into four perspectives regarding their relationship, shown in Fig. 1: No statement or no relationship, unclear relationship, and integration of social acceptance into S-LCA and vice versa, where the integration is pursued to varying degrees.

At this point of research, social acceptance was deliberately not defined in an explicit way to minimize the danger of missing important work. This led to the use of a variety of search terms which are regarded as synonymous for some, and as polysemous for others: social acceptance, societal acceptance, socio-political acceptance, community acceptance, market acceptance, citizen acceptance, consumer acceptance, public acceptance as well as all combinations with acceptability instead of acceptance – to ensure articles lacking a distinction between the terms are not left out. Perception is understood as an element of acceptance, not used as a synonym, following Huijts et al. (2012). Even though the words "social" and "societal" are no synonyms, they are often used interchangeably and can influence both social acceptance and S-LCA search results. Therefore, no clear distinction was made but instead an asterisk was used, to include all possible related terms: "social", "societal" and "socio-political" are expressed as "soci*". To further reduce search terms, the same applies to "acceptance" and "acceptability", which is searched as "accepta*". No constraints about technologies were applied.

Search terms in relation to S-LCA are: Social Life Cycle Assessment, S-LCA, SLCA, S LCA, social LCA, societal LCA, social life cycle, societal life cycle, social life-cycle, societal life-cycle, social sustainability assessment, societal sustainability assessment, social assessment, societal assessment, social hotspots and societal hotspots. Again, for "social" and "societal" a wildcard was used "soci*".

Scopus and Web of Science serve as search engines, even though Web of Science is criticized in relation to reviews of social acceptance (Wolsink 2018). The defined terms were searched within the title of the article, the abstract and the keywords provided by the authors. The publication year of the first version of UNEP/SETAC guidelines (Benoit et al.) in 2009 was taken as an starting point to conduct S-LCAs with an available framework. The filter for publication year was therefore set from 2010 to 2024. All document types written in English were used to provide an international understanding.

In total 33 articles were identified in the first search round. Screening through some articles revealed a high number which did not have any connection to S-LCA, but other social assessment techniques, which are not considered in this study. Therefore, the search strings of S-LCA were refined by removing "soci* sustainability assessment" and "soci* assessment" and applied in another search round. In addition, the limitation of publication years was removed.

In the following, the final search queries are provided.

Scopus: ((TITLE-ABS-KEY("soci* accepta*") OR TITLE-ABS-KEY("soci*-political accepta*") OR TITLE-ABS-KEY("community accepta*") OR TITLE-ABS-KEY("marketaccepta*")ORTITLE-ABS-KEY("citizen accepta*") OR TITLE-ABS-KEY("consumer accepta*") OR TITLE-ABS-KEY("public accepta*")) AND (TITLE-ABS-KEY("soci* Life Cycle Assessment") OR TITLE-ABS-KEY("S LCA") OR TITLE-ABS-KEY("soci* LCA") OR TITLE-ABS-KEY("soci* life cycle") OR TITLE-ABS-KEY("soci* hotspots")))

Web of Science: 1"TI=(""Soci* accepta*"") or AB=(""Soci* accepta*"") or AK=(""Soci* accepta*"")" 2"TI=(""Soci* -political accepta*"") or AB=(""Soci* -political accepta*"") or AK=(""Soci* -political accepta*"")"3"TI=(""community accepta*"") or AB=(""community accepta*"") or AK=(""community accepta*"")"4"TI=(""market accepta*"") or AB=(""market accepta*"") or AK=(""market accepta*"")"5"TI=(""citizen accepta*"") or AB=(""citizen accepta*"") or AK=(""citizen accepta*"")"6"TI=(""consumer accepta*"") or AB=(""consumer accepta*"") or AK=(""consumer accepta*"")"7"TI=(""public accepta*"") or AB=(""public accepta*"") or AK=(""public accepta*"")"8"#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7"9"TI=(""Soci* life cycle assessment"") or AB=(""Soci* life cycle assessment"") or AK=(""Soci* life cycle assessment"")"10"TI=(""S LCA"") or AB=(""S LCA"") or AK=(""S LCA"")"11"TI=(""Soci* LCA"") or AB=(""Soci* LCA"") or AK=(""Soci* LCA"")"12"TI=(""Soci* life cycle"") or AB=(""Soci* life cycle"") or AK=(""Soci* life cycle"")"13"TI=(""Soci* hotspots"") or AB=(""Soci* hotspots"") or AK=(""Soci* hotspots"")"14"#9 OR #10 OR #11 OR #12 OR #13"15"#8 AND #14)"

The number of documents without duplicates was now 17. They were complemented by two articles which were known by the authors prior to the literature review. Each document was reviewed for links between S-LCA and

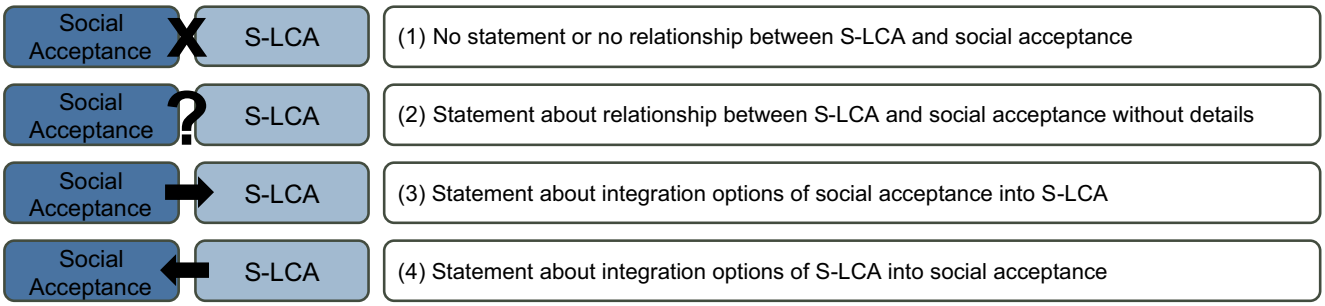

Fig. 1 Relationships between S-LCA and social acceptance identified in literature

Table 2 Search process for systematic literature review; n - search hits

Social Life Cycle Assessment	Social Acceptance
Definition of search strings	
("soci* Life Cycle Assessment")	("soci* accepta*")
("S LCA")	("soci*-political accepta*")
("soci* LCA")	("community accepta*")
("soci* life cycle")	("market accepta*")
("soci* hotspots")	("citizen accepta*")
	("consumer accepta*")
	("public accepta*")
Scopus and Web of Science, 11.02.2025	
Scopus	n = 17
Web of Science	n = 13
- Dublicates	n = 13
+ Known literature	n = 02
+ Snowballing from all literature	n = 25
Total	n = 44
- Excluded	n = 18
Documents reviewed	**n = 26**

social acceptance. With the snowball method another 25 articles were identified, adding to a total of 44 articles. 18 articles were excluded due to the lack of a relation to S-LCA, to social acceptance or because the original sources were unavailable. This was partly due to language barrier, since only the abstract was published in English. Other reasons were that the sources were not retrievable online or through library collections. The remaining 26 articles include a relation to both S-LCA and social acceptance and were reviewed to answer how the relationship between S-LCA and social acceptance is presented in literature. An overview of the literature research process and the search hits is shown in Table 2.

3 Results

The result section provides an analysis of literature regarding its bibliographic information (3.1) and the current state of the art of relationships between S-LCA and social acceptance (3.2). Both sections are part of the second level of

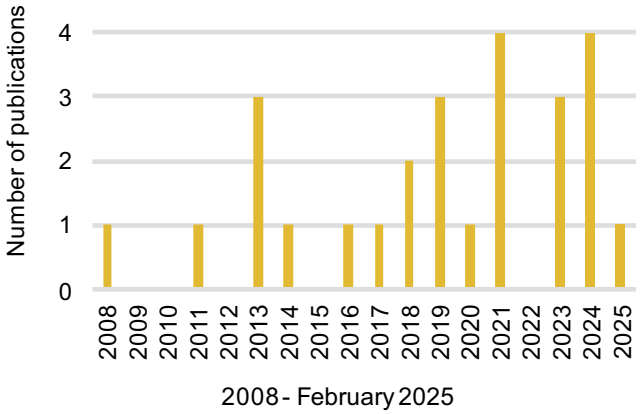

Fig. 2 Number of publications per year since 2008

this study. The latter divides the publications into different types of relationships: Sect. 3.2.1. includes publications with either no relationship or no statement about it. Section 3.2.2. encompasses publications with rather broad statements about the relationship whereas the publications in Sect. 3.2.3. provide specific suggestions for combining S-LCA and social acceptance by conducting a S-LCA. Finally, Sect. 3.2.4 presents a publication in which a combination is presented vice versa, i.e. the use of S-LCA for social acceptance.

3.1 Bibliographic information

As a result of the systematic literature review, 26 publications were analyzed. This was done with respect to the year of publication (Fig. 2), the S-LCA impact assessment type, the location of the corresponding author (Fig. 3) and the sector which was addressed by the publication (Fig. 4). In addition, the scientific journal (Fig. 5) and author affiliations were examined (Supplementary information, Table S1).

It appears that social acceptance is a topic that has been addressed in the context of S-LCA research for many years. However, based on the criteria of the systematic search, which was limited to titles, abstracts, and keywords, this impression cannot be fully substantiated. Nevertheless, an

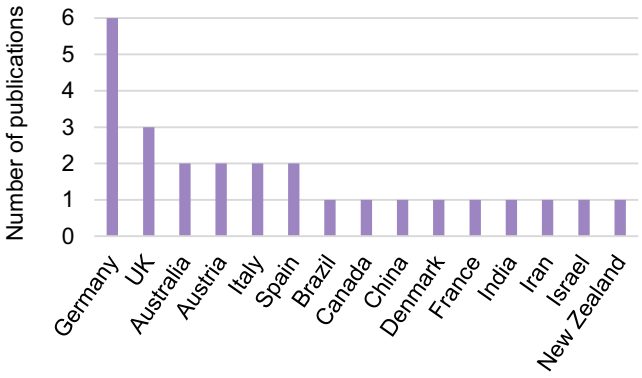

Fig. 3 Number of publications by country of the corresponding author affiliation

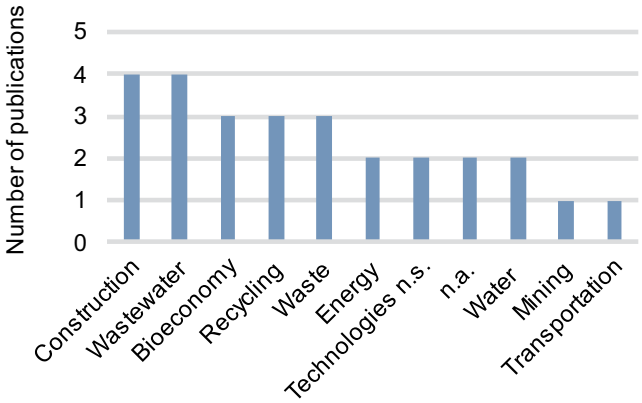

Fig. 4 Number of publications by sector; n.a. – not applicable, n.s. – not specified

examination of the publication years indicates that the connection is gaining importance. The first article fulfilling the stated search criteria was published in 2008. Until 2025, a slight increase can be observed in Fig. 2. The systematic literature review was conducted in February 2025.

Out of 26 publications, 19 address specific impact assessment methods, and all of them refer to a reference scale approach, now called S-LCPA. They either apply it in their case study or include it in their methodological advancements, e.g., S-LCA frameworks. None of the articles consider an impact pathway approach (S-LCIA).

Figure 3 shows the number of publications by the country location of the corresponding authors. Germany has the highest number of publications ($n=6$). All countries with more than one publication, except Australia, are located in Europe.

In terms of sectoral distribution, the construction and wastewater sectors are the most frequently addressed, followed by the sectors bioeconomy, recycling and waste. Lehmann et al. (2011) deals with two separate cases (waste and water), which is why the total number of Fig. 4 equals 27. The energy sector, which is prevalent in public discussions, is the focus of two publications. Another two articles address unspecific technologies and two the management of water. There are articles which show no connection to a specific sector but instead focus exclusively on methodological issues. In the future, social acceptance is likely to become a relevant topic for other areas, e.g., cell-based meat or insects as a food source.

All 26 publications were published in journals of environmental and sustainability science, as illustrated in Fig. 5. The majority ($n=19$) of them are part of journals commonly used in the research of S-LCA (The International Journal of Life Cycle Assessment, the Journal of Cleaner Production and Sustainability). This general trend of the most frequently used journals is also proven by Rebolledo-Leiva et al. (2023) and Tokede and Traverso (2020). Surprisingly, none of the articles were published in an academic journal in the field of social science.

The same can be observed in the analysis of author affiliations. None of the listed affiliations fall within the domain of social science. Most institutes, departments, chairs etc. belong to civil engineering, environmental science, waste

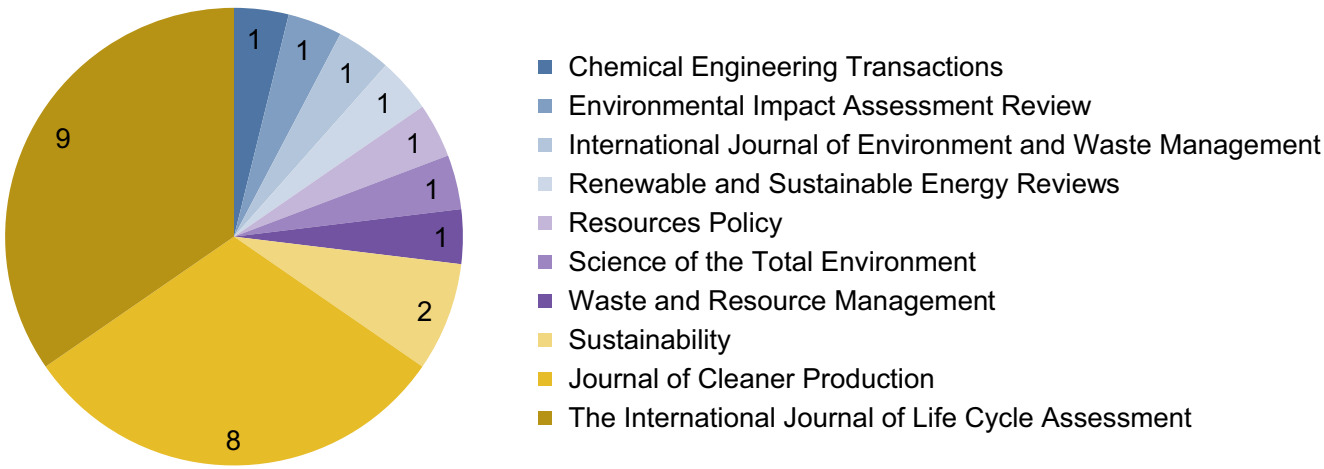

Fig. 5 Number of publications per journal

management, technologies or energy. The comprehensive list of author affiliations is provided in the supplementary information, Table S1. It should be noted, however, that the name of an institute, department, etc. alone does not necessarily provide information about which academic disciplines are addressed within it. Furthermore, considering the authors' affiliations in isolation does not allow for conclusions to be drawn about their individual disciplinary backgrounds. Nevertheless, a potential lack of social science affiliations could be a limitation for the overall research area, if valuable exchange of interdisciplinary knowledge is missing.

3.2 Relationship between S-LCA and social acceptance in literature

The 26 articles identified within the systematic literature review were divided into the four perspectives defined in the Method section (2.2), each showing a different relationship between S-LCA and social acceptance. The first perspective includes ten, the second four publications, while the fourth only includes one publication. Perspective 3 comprises twelve publications and has the highest number among them. One publication is assigned to two perspectives.

3.2.1 No statement or no relationship between S-LCA and social acceptance

Within the first perspective, eight of the ten articles address both topics, but do not make any statement about the relationship between S-LCA and social acceptance. For example, Zafar et al. (2024) understand the knowledge of policy makers and governing bodies of social impacts as a driver for social acceptability, but there is neither a statement about how social acceptance is defined, nor how it is or could be connected to S-LCA. Several other publications conducting S-LCAs also state the importance of social acceptance, but do not draw any methodological connections between the two (Aparcana and Salhofer 2013; Berticelli et al. 2020; Janjua et al. 2019; Mancini and Sala 2018; Opher et al. 2019; Siebert et al. 2018a; Zhou et al. 2019).

Another two articles by Martín-Gamboa et al. (2025) and Luthin et al. (2023b) conclude in their studies that social acceptance/public acceptance is not included into S-LCA yet.

3.2.2 Statement about relationship between S-LCA and social acceptance without details

The second perspective includes four articles, which make statements about relationships between S-LCA and social acceptance, but do not provide further details about it. For example, Furness et al. (2021) identify knowledge gaps in S-LCA for the assessment of wastewater. They recommend considering public acceptance of resource recovery in S-LCA with neither explanation of the meaning of public acceptance nor further details about arguments or implementation options.

Iacovidou et al. (2017) review different social metrics and their potential within resources that are recovered from waste. "Acceptability" is used as a criterion/metric and referenced, among others, to the old version of the UNEP guidelines (Benoit and Mazijn 2009), but without any further connection to S-LCA.

Jørgensen et al. (2008) screened S-LCA approaches in respect to the inclusion of "Local community acceptance" as midpoint impact categories and indicators. The authors claim to have identified it in different publications (such as (Gauthier 2005; Méthot 2005; Nazarkina and Bocq 2006; Schmidt et al. 2004; Spillemaeckers et al. 2004)). Of those publication's, Schmidt et al. (2004) refer to S-LCA but do not use any social acceptance term. A preliminary list of social indicators is provided but it remains unclear which ones are considered to cover the acceptance topic. It was not possible to access the publication by Nazarkina and Bocq (2006)[1]. Siebert et al. (2018b) state "Local community acceptance (complaints)" as a social aspect within S-LCA and refer for that statement to Hosseinijou et al. (2014).

3.2.3 Statement about integration options of social acceptance into S-LCA

Twelve articles are categorized in the third perspective, all providing concrete proposals for the integration of social acceptance into S-LCA at varying degrees. They are displayed in Table 3. The majority creates new impact categories, subcategories and/or indicators for social acceptance and include them into S-LCA, either theoretically or within case studies. Some authors reinterpret existing ones.

Lehmann et al. (2011) use the existing subcategory "Feedback mechanism" from the first version of the UNEP guidelines (Benoit and Mazijn 2009) to include social acceptance in a case study by stating that "The subcategory can be used for reflecting the acceptability of technologies from a user (consumer) perspective." According to the authors, adequate implementation of technology is, among others, dependent on social acceptance. Also, the willingness to pay and the overall welfare of stakeholders are reliant on social acceptance. The latter can be regarded as a social impact in the logic of S-LCA.

In a follow up case study, Lehmann et al. (2013) state, "Acceptance includes aspects such as involvement of the

[1] Several attempts to obtain the publication including a library request, purchase attempts, and contacting the author, were unsuccessful.

Table 3 Articles containing concrete suggestions for integration options of social acceptance into S-LCA (perspective 3); n.r. – not reported

Reference	Stakeholder	Impact category	Impact subcategory	Indicator	Potential data sources	S-LCA alignment
Lehmann et al. (2011)	Consumer	-	Feedback mechanisms	-	n.r.	yes
Lehmann et al. (2013)	Local community	Acceptance of technologies (relevant for successful technology transfer and use of technologies)[a]	Community engagement	Public trust of politicians	n.r.	yes
	Local community	Acceptance of technologies (relevant for successful technology transfer and use of technologies)[a]	Cultural heritage	Is relevant information available to community members in their spoken language	n.r.	
	Consumers	Acceptance of technologies (relevant for successful technology transfer and use of technologies)[a]	Feedback mechanism	Mechanism for consumers exist to provide feedback	n.r.	
	Society	Acceptance of technologies (relevant for successful technology transfer and use of technologies)[a]	Corruption	Risk of corruption in sector	n.r.	
Aparcana et al. (2013)	Workers	Society[b]	Social acceptance/social inclusion	Perception and acceptance of the recycling activities by citizens	Previous studies and interviews	yes
Hosseinijou et al. (2014)	Local community	-	Local community acceptance	Presence of complaints by local community	Stakeholder and expert interviews	no
Bezama et al. (2021)	Trainees, local community	Knowledge capital[c]	Vocational training[d]	Rate of vocational trainees	n.r.	yes
Bouillass et al. (2021)	User	-	Affordability and accessibility	-	n.r.	no
Foglia et al. (2021)	City/Society	-	-	Social acceptance	Questionnaires	no
	Consumers	-	-	Social acceptance	Questionnaires	
Luthin et al. (2023a)	-	Social acceptance	Technical uncertainties and obstacles	-	Industry contact, literature, project partner	yes
			Concerns related to health risk	-	Industry contact, literature, project partner	
Tarpani and Azapagic (2023)	Investor/operator/supplier	Technology adoption[e]	-	Adoption risk	Literature	no
	Community and consumer	Acceptance[e]	-	Public opposition	Literature	
			-	Dissimilarity from traditional products	Literature	
Gehlot and Shrivastava (2024)	-	-	Social acceptance	-	Online survey	no

Table 3 (continued)

Reference	Stakeholder	Impact category	Impact subcategory	Indicator	Potential data sources	S-LCA alignment
Hannouf et al. (2025)	Companies as users/consumers	-	Complexity associated and applicability	-	Interviews, questionnaires	yes
		-	Perceived risk associated (social, political, technical)	-	Interviews, questionnaires	
	Local Community	-	Perceived risk associated (social, political, technical)	-	Interviews, questionnaires	
		-	Projected benefit	-	Interviews, questionnaires	
Garfí et al. (2025)	Consumer	Human Rights	Acceptability	Acceptance level	Survey (primary data), use United Nations (2010) for evaluation	no

[a] Authors call it general aspect (not social impact category)
[b] Authors call it impact category (not stakeholder)
[c] Authors call it index (not social impact category)
[d] Authors call it sub-index (not social impact subcategory)
[e] Authors call it social issue (not social impact category/subcategory)

community in decision processes in order to consider their needs or expectations regarding (alternative) technologies.”. This can be considered a social impact. They define the aspect of “Acceptance of technologies (relevant for successful technology transfer and use of technologies)” with several subcategories and indicators from the UNEP guidelines (Benoit and Mazijn 2009) and methodological sheets (Benoit Norris et al. 2013) for the local community, consumers and society – especially for the implementation of technologies. For the former stakeholder group, “Community engagement” a subcategory with the indicator “Public trust of politicians” is introduced. “Cultural heritage” is a subcategory and measured with an indicator asking for the availability of relevant information to community members. Consumers are addressed with the subcategory “Feedback mechanism” and the indicator “Mechanism for consumers exist to provide feedback”. For the latter group, society, “Corruption” as a subcategory is complemented with the indicator “Risk of corruption in sector”. Lehmann et al. (2013) was known by the authors and not an outcome of the literature search, as it does not contain any social acceptance related terms in the title, abstract or the keywords.

Aparcana et al. (2013) develop a S-LCA method especially for recycling systems in developing countries. They include “Social acceptance/social inclusion” as a new impact subcategory within the impact category “Society” and the indicator “Perception and acceptance of the recycling activities by citizens“and suggest taking data from previous studies and interviews. Neither the recycling activity nor technology are the center of attention. Instead, the question of how the job of the workers is socially accepted by society is addressed. In a case study, they interviewed workers about their feeling of acceptance from the citizens. Assessing this feeling can be regarded as a social impact and thus aligns with the S-LCA logic. The authors state that “The more positive is the feedback of citizens in relation to these recycling activities, the better the recyclers feel about their role within the society. They feel accepted as an important and meaningful part of their social milieu.” (Aparcana et al. 2013).

The subcategory “local community acceptance” with the indicator “Presence of complaints by local community“is listed by Hosseinijou et al. (2014) with a reference to UNEP/SETAC methodological sheets of 2010, which is no longer accessible online through the former URL[2]. Within their developed method and case study, they interview stakeholders and experts to generate data. There are neither

[2] The reference provided in Hosseinijou et al. (2014) is: “UNEP/SETAC (2010) Methodological sheets for 31 sub-Categories of impact for a social LCA of products. www.estis.net/sites/lcinit/default.asp?site=lcinit&page_id=A8992620-AAAD-4B81-9BA-CA72AEA281CB9. Accessed January 2013”.

statements of how they understand social acceptance, nor arguments to assess it within S-LCA, and therefore, no S-LCA alignment is given.

Bezama et al. (2021) draw the link between S-LCA to social acceptance over trainees, a stakeholder group rarely addressed in S-LCA[3]. They argue that "[…] the involvement of trainees can bring further positive impacts in the value chain, such as an increased connection to the local community and thus a better social acceptance towards the production facilities." Social acceptance is included within the index "Knowledge capital" and sub-index "Vocational training", measured with the indicator "Rate of vocation trainees" in their case study. As they define the connection to the local community as a social impact, S-LCA alignment is given, even though an argument for this is missing.

The subcategory "Affordability and accessibility" for users is developed as a new impact subcategory by Bouillass et al. (2021) within a newly developed framework for a participatory approach in S-LCA. They state that it could be a factor influencing social acceptance, referring to a Life Cycle Costing study by Tseng et al. (2013). They did not apply it in their case study due to a lack of data. The reason for including users is the potential market integration risk resulting from a lack of social acceptance. Therefore, it cannot be regarded as having a social impact and does not align with the S-LCA logic. The article by Bouillass et al. (2021) was not a result of the literature search but known by the authors.

The case study by Foglia et al. (2021) focuses on wastewater and highlights its safe treatment as well as the legal conformity seen as essential when it comes to public acceptance. They established social acceptance as indicators for the stakeholder's city/society and consumers. For the former, social acceptance is defined as "Level of acceptance for innovative technologies and products by society" and the same for consumers "[…] by citizens". Data is sourced from questionnaires. Their goal to assess social acceptance can be considered as being of economic, rather than of social motivation as they argue with market adaptation. Therefore, it is not in alignment with the S-LCA impact logic. The procedure of assessment remains somewhat confusing. On the one hand, stakeholder names are not used uniformly. On the other, their defined indicators for workers (training, operative risks, working hours and expertise) are described as being factors influencing social acceptance, but are not set into relation with their social acceptance indicators. This poses the risk of double counting.

Luthin et al. (2023a) add social acceptance in their case study on the construction sector as an additional impact category of a social hotspot assessment with two subcategories "Technical uncertainties and obstacles" and "Concerns related to health risk", as a potential burden for implementation. Thus, they use an economic as well as a social argument for the integration of social acceptance and therefore, align with S-LCA impact logic. Industry contacts, literature and project partners are used as data sources.

Tarpani and Azapagic (2023)[4] connect the term acceptance with adoption risk, addressing the stakeholder groups of investors/operators/suppliers, where adoption risk is defined as "[…] the technology readiness level of each technology and the potential demand and acceptance of its products". The corresponding social issue is „Technology adoption" (Indicator "Adoption risk"). For the stakeholders of community/consumers, the focus is placed on possible adoption barriers as well, with the social issue "Acceptance" (Indicators "Public opposition", "Dissimilarity from traditional products"). As adoption risk cannot be considered a social impact, no S-LCA alignment is given. Literature, in general, is used as a data source in the case study.

The case study conducted by Gehlot and Shrivastava (2024) takes social acceptance as a subcategory and cites Benoît-Norris et al. (2011), even though social acceptance or any related term cannot be found in the referenced literature. There is no reason given why social acceptance is assessed.

Hannouf et al. (2025) are concerned with the development of technology systems and differentiate the application of S-LCA between technical readiness levels (TRL) with the goal to meet drivers for technologies that are socially acceptable and implementable. To pursue this, they integrate factors influencing communication and social acceptance into S-LCA by creating new subcategories for the assessment with TRLs between 4 and 7. For companies as consumers the subcategory "Complexity associated and applicability" shall address the "complexity if any and its impact on the successful implementation and application of technology in the future". Absent social acceptance is seen as a potential burden. The second new subcategory "Perceived risk associated (social, political, technical)" for companies as consumers shall cover comparison of risks of the future application of the technology vs. risk of current technologies. Both cannot be considered as social impacts, but another subcategory with the same name "Perceived risk associated" can be considered a social impact und thus aligns with the S-LCA logic. It was newly implemented for the local community,

[3] Whether trainees are an own group of stakeholders, belong to the group of workers or to the group of children, as suggested by (UNEP 2021), depends on the individual assessment.

[4] Neither the title, abstract nor the keywords contain the search stings used within this literature review, but the article still appeared in the results of the literature search in Scopus. The reason is that searching in the field "keywords" in Scopus includes indexterms as well. More information can be found at Elsevier (2025). "Social acceptance" is listed as a medical term of EMTREE in this reference. Nevertheless, as the article is relevant to this study, it is included.

including Indigenous People and "assesses if there is any associated risk on community based on information provided by technologies developers to communities' representatives on technology features and sustainability and social impacts." (Hannouf et al. 2025). The fourth new subcategory "Projected benefit" shall address the potential benefits and can be regarded as a social impact as well. Interviews and questionnaires are suggested as potential data sources.

The goal of a technology development which meets "all drivers for acceptable and implementable technology" (Hannouf et al. 2025) is the reason for the integration of these factors (which can influence social acceptance) into S-LCA. This goes hand in hand with the integration of S-LCA into social acceptance – representing a fourth perspective. More details can be found in Sect. 3.2.4.

A new impact subcategory "Acceptability" with the indicator "Acceptance level" for consumers is defined by Garfí et al. (2025) for an SO-LCA and as a result of an materiality assessment. In a case study, Performance Reference Points are used to evaluate the indicator with primary data from surveys. As no sufficient information is provided, no S-LCA logic becomes evident.

In all twelve articles of the third perspective, drawn connections always integrate social acceptance into S-LCA, using existing or creating new impact categories, subcategories and/or indicators – except Hannouf et al. (2025), where both integration sides are addressed. The overarching argument to assess social acceptance is mostly bound to its important adoption condition on the market, but often without further definition of social acceptance (Bouillass et al. 2021; Foglia et al. 2021; Hannouf et al. 2025; Lehmann et al. 2011, 2013; Luthin et al. 2023a; Tarpani and Azapagic 2023). One article by Aparcana et al. (2013) introduces the feelings of the workers as an argument. All articles are based either exclusively on case studies or on a combination of case studies and theoretical work involving practical application, with only one article being purely theoretical (Luthin et al. 2023b).

The topics of newly created impact categories, subcategories and indicators vary widely and reflect the heterogeneity of social acceptance interpretations and the factors influencing it. This results in varying degrees of integration. For two articles, the integration is rather diffuse, as they are unclear and/or contradictory at some points. There are six articles with coherent methodological integration, where the impacts are mostly detailed by providing different layers, e.g., impact categories, subcategories and/or indicators. Within the coherent methodological integration, statements for the integration are provided and align with the S-LCA impact logic (Sect. 2.1), by labelling social acceptance as a social impact to be assessed within S-LCA. Four of these articles raise the additional argument that social acceptance poses a risk to market adoption. This is regarded as an economic, rather than a social aspect and therefore considered as not being in alignment with S-LCA. Another six articles follow a nominal integration with partial detail but lack systematic justification. They do not correspond to the S-LCA impact logic, as they only highlight the importance of market adoption. The two interpretations of social acceptance are shown in Fig. 6.

This observation is crucial, as it highlights the vulnerability of language to misinterpretation. In this case, social acceptance appears to be social at first glance; however, upon closer inspection, its classification depends on the underlying interpretation and definition.

The most used terminology includes "acceptance". Some impact categories and subcategories are designed on a general level, e.g., acceptance, perceived benefits, perceived

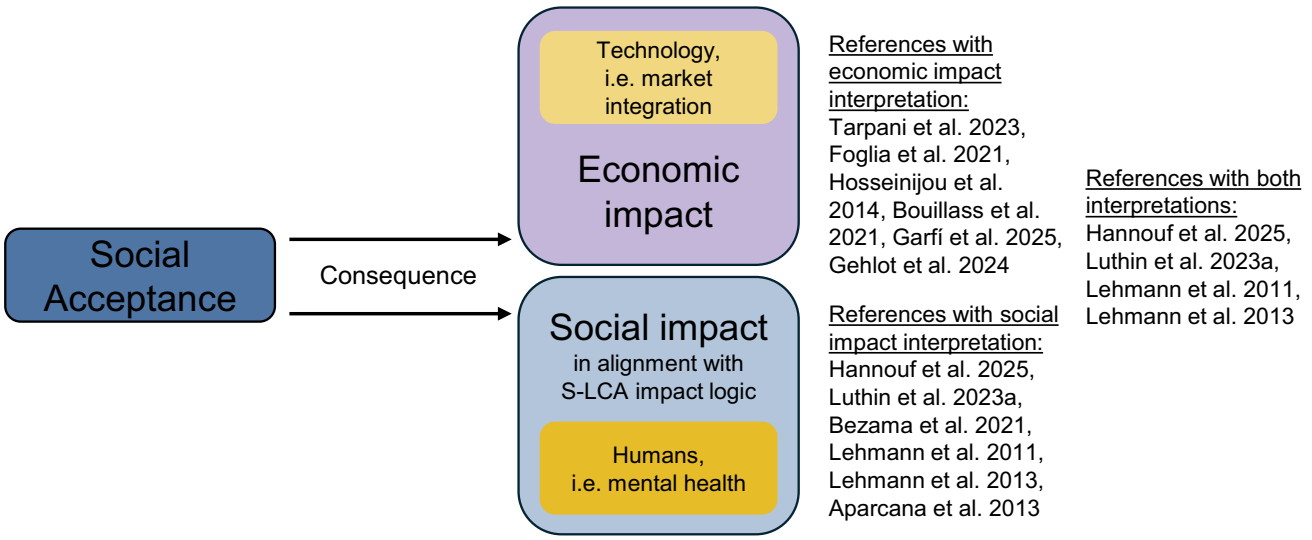

Fig. 6 Interpretations of social acceptance from literature

risk, others are rather specific to the context of the study, e.g., knowledge capital and vocational training. In addition, potential data sources were not always reported.

Due to the lack of a clear definition of social acceptance, some articles pose the risk of double counting. For example, where factors potentially influencing the social acceptance of people, such as health risks, are assessed in parallel to social acceptance impact categories etc.

The most considered stakeholder groups are consumers (six articles), including companies as consumers (one article) and the local community (six articles). Only two articles target the society and only one value chain actors in a distant form (investor, operator, supplier). Workers are assessed by three articles. The suggested data sources entail primary as well as secondary sources, e.g., previous studies, interviews, questionnaires, literature, project or industry contacts and online surveys.

3.2.4 Statement about integration options of S-LCA into social acceptance

Hannouf et al. (2025) state that selected S-LCA subcategories of UNEP (2020) can improve technology developers' comprehension of social impacts, which enables them to identify social impacts for improvement, and processes where stakeholders are to be involved – both with the goal to add to social acceptance. In addition to the new subcategories for social acceptance in Sect. 3.2.3, they create new ones to assess the communication between stakeholders and developers. Therefore, the article is part of the third as well as the fourth perspective.

4 Discussion

The discussion includes all levels of this study, each adding to the fundamentals for a framework. It starts with the main findings (Sect. 4.1), which includes the results of the systematic literature review as well as the characteristics of S-LCA and social acceptance. It is followed by Sect. 4.2, which presents a conceptualization of social acceptance in the context of S-LCA. Section 4.3 discusses initial approaches to combine S-LCA and social acceptance beyond those identified in the literature.

4.1 Main findings

Both S-LCA and social acceptance are topics that might be encountered in the context of social sustainability – from a research perspective as well as from a market view. Although this research explains the concepts of S-LCA and social acceptance and reveals their relationships, certain limitations remain.

Many definitions shown within this article stem from energy technology research. The literature review is, nevertheless, not restricted to any specific sector. There are multitudes of different understandings of social acceptance with respect to the underlying definitions and terminologies used, which makes it challenging to assess it in a literature review. On the one hand, this divergence leads to the danger of misinterpretation. If used in combination with S-LCA the need to clarify words and concepts becomes even larger. On the other hand, due to the different terminology, some articles may have been omitted during the search process of this study. In the future, this can be addressed with a broader variety of search terms, e.g., including "perception" and "attitude" for social acceptance search strings.

A similar situation can be observed regarding S-LCA. Even though S-LCA is a technique with a determined framework, the terminology as well as their notation can differ greatly in practice. The overall technique of S-LCA has not changed in consequence of ISO 14075 (2024), but is rather more specified and includes recent developments and advancements. Nevertheless, in direct comparison to the UNEP (2020) guidelines, differences in, e.g., the methodology, and terminology are present. None of the reviewed literature takes into account the new ISO 14075 (2024), as it was published in October 2024 and therefore later than most of the articles. In addition, there are open issues and challenges within the methodology. How these will develop in the future remains to be seen. Search terms such as "Social-Life-Cycle-Assessment", "Social impact assessment", or "Social Footprint" could be integrated into the search functions of future reviews. Including the word "analysis" in "Social Hotspot Analysis" and "Social Life Cycle Analysis" does not affect the search results. Likewise, there is no difference between "hotspots" and "hotspot".

None of the publishing entities of the identified articles appear to have a primary focus on social science. This may represent a drawback for the broader research field that seeks to connect S-LCA and social acceptance. For both S-LCA and social acceptance, expertise is indispensable to ensure accurate assessment and valid conclusions. Hence, interdisciplinary collaborations are essential. Nevertheless, the assumption within the literature review that S-LCA is less commonly carried out by researchers with a social science background, should be interpreted with caution. Authors' affiliations were screened based on the names of institutes, departments, etc. However, this does not provide a definitive indication of their research focus, which could still encompass social science.

The literature review showed that authors who address both S-LCA and social acceptance within one article, do not

necessarily combine them. Others made vague statements about S-LCA and social acceptance without providing further details. In addition, the lack of clear definitions for both makes it challenging to fully convey their content in a precise and coherent manner.

One argument for conducting a parallel standalone assessment of S-LCA and social acceptance is that they are two distinct concepts that are independent of each other. For example, as social acceptance analysis usually does not have a life cycle perspective and is mostly targeted at the local community and consumers, it could also be part of a classic risk assessment, instead of an S-LCA. While a combination of the two provides an overview of social topics, the depth of the results might be impaired.

Most of the literature integrates social acceptance into S-LCA, implemented by the creation of new impact categories, subcategories and indicators or the reinterpretation of existing subcategories. Garfí et al. (2025) drew a connection between S-LCA and social acceptance with a materiality assessment, where "Acceptability" was identified as material for consumers. Hannouf et al. (2025) carried out a targeted integration of social acceptance into S-LCA. Their understanding of social acceptance is not stated. The newly implemented subcategories are defined in a general way, which could lead to differing interpretation about what could be a risk and a benefit, which are perceived as being specific risks and benefits. In addition, they state that the provision of information through S-LCA leads to an increase of the social acceptance level, but this is controversial within the social acceptance research field and demands further discussion.

Studies, especially in the context of climate engineering, e.g., CCS, showed that more information decreases the social acceptance of stakeholders (Braun et al. 2018; Schumann 2010; Valencia Cotera et al. 2026), whereas others found that the provision of information can foster acceptance, e.g., for smart energy in households (Shamon et al. 2021). Nevertheless, these technology-specific results, particularly for highly controversial and context dependent topics such as CCS, cannot be directly transferred to other areas, time horizons or technologies, given that social acceptance is dependent on many different factors. Even more importantly, this does not mean that information should be withheld. Information is necessitated to form an opinion (Valencia Cotera et al. 2026) and even depicts a human right according to article 19 of the Universal Declaration of Human Rights United Nations (1948).

The effect of information on social acceptance can just be as manifold as other factors. Not only the informative content itself and the trust in the source of information provided, but also its framing, might have an effect. In addition, public discourse in areas such as media, politics etc,. at that time can shape perceptions (Braun et al. 2018). This is grounded in relational sociology, which states that society is a network, where actions and events are influenced and connected by each other, its actors, future interactions etc. (Crossley 2011). For example, studies on relational perspectives highlight the influence of, e.g., emotions and identity on decision-making (Middlemiss et al. 2024) and are addressed, among others, within the relational co-productionist approach by Chilvers and Longhurst (2015). From this perspective, "information" itself would not be regarded as an isolated determinant that leads to increased or decreased social acceptance.

With respect to S-LCA, the provision of information through S-LCA results should not be considered to increase social acceptance, but rather to enable individuals to form free opinions. By doing so, the information must be communicated in a transparent manner, as it can be connected to trust, which, in turn, can be a major factor influencing social acceptance (Emodi et al. 2021; Schmidt and Stybel 2025). In addition to the mere provision of information, its communication is required to obtain feedback from, and to involve, the public (Braun et al. 2018). Especially participatory processes, e.g., informative events, dialogues, townhall meetings etc. or co-creation can add to trust, transparency and acceptance, even though they not automatically lead to acceptance (Radtke 2025).

Children and smallholders, stakeholders only occasionally addressed in S-LCA, are not considered by any article. The most addressed stakeholder groups are the local community and consumers. Workers were rarely considered as stakeholders addressing social acceptance. The study by Aparcana et al. (2013) explained the influence of citizens acceptance on workers as being positive for their feeling about their job. Bezama et al. (2021) addressed, next to the local community, trainees, which could be regarded as workers. Luthin et al. (2023a) does not name a specific stakeholder group but seems to address workers.

As the workforce is inevitable in every sector, they can play a major role in social acceptance of technologies and should therefore be included in the analysis. Their expectations may be partially met through the involvement of the local community of which they are part of, but they may have additional expectations related to their role as employees. For example, working conditions like working hours or the working environment, job security, reputation of the company or entry requirements such as specialized training.

In addition, a low level of overall social acceptance can be a constraint for other stakeholders such as the company implementing the technology. However, this risk for companies as the impacting entity is not considered in the classic view of S-LCA. Nevertheless, it must be kept in mind that

this form of combination can induce a loss of information or can create the risk of double counting.

About half of the studies are in alignment with the S-LCA impact logic, whereas the other half considers the economic impact of a potential market failure as the driving force to assess social acceptance. This adds to a variety of different degrees of integration. While some authors use more general terms of acceptance, e.g., social acceptance or local community acceptance, others draw attention to more specific interpretations such as public participation (e.g., feedback mechanism, community engagement), trust (e.g., public trust of politicians, corruption) or technological aspects (e.g., complexity associated and applicability). This increases the variety of degrees of integration even further.

A hydrogen technology related framework from Zamagni et al. (2025), published after the completion of the literature review, adopts a different perspective on the relationship between S-LCA and social acceptance. Within their conceptual framework, they regard social acceptance not as a social impact which has to be assessed, but rather as a process influenced by technology specific and additional aspects such as safety and affordability. They state that "Depending on the outcomes of the evaluation of the identified social aspects, it is possible to conclude on a potential acceptance of the technology […]. Thus, acceptance represents the results of the assessment process." (Zamagni et al. 2025).

The integration of social acceptance into S-LCA might be different depending on the S-LCA study type. While within an S-LCPA complex information could be broken down, an S-LCIA could provide insight into the cause and effect of factors and in turn, the impact from social acceptance on stakeholders. It is advantageous to include expertise from social science to be able to define impact pathways. In both cases, S-LCA might not be suitable depending on the goal and scope of the assessment. For example, technical information or consequences for the environment are likely to be part of other assessment techniques, which is, however, not a constraint to include them in S-LCA. When it comes to data sources, the lack of data to assess social acceptance depicts a hurdle. Nevertheless, secondary data might be available from other studies.

A major improvement in integrating social acceptance into S-LCA is the chance to broaden the assessment of social acceptance to additional life cycle stages. This generates a more comprehensive and holistic assessment as knowledge about social acceptance could not only be important for the implementation of technologies but also in other parts of the life cycle. However, this remains a promising area for future investigations, especially for background systems of S-LCAs.

4.2 Conceptualization of social acceptance in the context of S-LCA

The results in Sect. 3.2 show that different perspectives are pursued by the reviewed articles, when it comes to the relationship between S-LCA and social acceptance. In addition, for articles which integrate social acceptance into S-LCA (Sect. 3.2.3), by creating new or reinterpreting existing impact categories, subcategories or indicators, there is a high variety. Across all twelve articles employing this perspective, it appears that social acceptance represents a social impact due to its integration into S-LCA. Yet, a closer analysis shows that only some of the articles consistently maintain this view. Six articles integrate social acceptance into S-LCA but conceptualize a lack of social acceptance as a barrier to successful market introduction. This may be classified as an economic impact and therefore does not correspond to the impact logic of S-LCA. The absence of clear definitions poses a challenge, necessitating an interpretation of social acceptance that can be used in combination with S-LCA. As S-LCA alignment is a prerequisite, the view of social acceptance as an economic impact is not taken into account in this section.

Instead, the interpretation of social acceptance for this research is considered as being a response, attitude, behavior from humans, following Upham et al. (2015), which can have a social impact on humans (Fig. 7). This reflects the viewpoint of some S-LCA practitioners, e.g., Bezama et al. (2021). This interpretation therefore also supports the integration into S-LCA as a standardized impact category "social acceptance". Because of social acceptance being an attitude etc. of humans, the impact it has on them is always

Fig. 7 Interpretation of social acceptance as social impact on humans

of psychological nature. This should not be confused with the argument that social acceptance is not only a social topic (Huijts et al. 2012), as it is influenced by factors from all sustainability dimensions and beyond. While this is true, social acceptance as a social impact is centered on the outcome of social acceptance on stakeholders and therefore reasonable to be discussed in relation to S-LCA.

All stakeholder groups considered in S-LCA, i.e. workers, local community, value chain actors, consumers, society, and children, are assumed to potentially be impacted mentally by their social acceptance attitude. For example, the local community living in proximity to a technology can be annoyed, e.g. due to an aesthetic loss of natural beauty (Upham and Johansen 2020). They could also fear an image change or are affected by a changing character for their area (Schmidt and Stybel 2025). Workers may experience higher levels of satisfaction, less work-related stress or more work engagement (Shamsi 2025). Motivation may likewise increase as a result of a sense of pride. The same could apply to consumers, who may also be children. A positive attitude towards a technology could increase overall satisfaction or negatively affect it, if social acceptance is lacking. Impact on value chain actors may be less obvious. If intermediaries or suppliers do not socially accept a technology, this could place them in a difficult position, particularly if they are financially dependent on its distribution. Feelings of shame may also arise in such cases. Society as a whole could likewise be influenced by the presence or absence of social acceptance. However, as members of the stakeholder group society are often assigned to multiple groups in the context of S-LCA, these aspects are excluded from the interpretation in this study.

As described in the Introduction Sect. 1 and Sect. 2.1 various factors can influence the social acceptance of people, e.g., the technology itself and its location but also perceived costs, benefits and risks. This view is also adopted in this research. Therefore, it is suggested to define indicators and subcategories for S-LCA on an individual basis in dependance on the product to be assessed and, if applicable, on the functional unit of the study. For this reason, it is a prerequisite to know the specific factors which influence social acceptance to be able to translate them into indicators and subcategories. For example, the indicator "% of people who feel save within close proximity of the facility" could address fear of the local community. If an indicator is dedicated to consumers, it could address the impression of safe use to assess trust. The indicator "% of workers who are proud of their job" serves as an example for workers, to assess their pride, satisfaction or motivation.

Another prerequisite is to know the direction of effect of the factors, i.e. indicators, as a seemingly positive impact does not necessarily result in social acceptance. This knowledge could either be taken from other studies or be assessed separately. However, it should be noted that capturing social acceptance adequately using generic data remains a challenge. Although this is not recommended for S-LCA as well, generic data is nevertheless frequently used due to the limited availability of primary data.

It has to be noted that these factors could be part of other S-LCA impact categories, subcategories or indicators. For example, integrating "access to information", a factor possibly influencing the acceptance of CCS technologies (Valencia Cotera et al. 2026), into an impact category "social acceptance" without a clear distinction from the existing impact subcategory "access to immaterial resources" by UNEP (2020), which already includes access to information, may lead to overlaps (UNEP 2020, 2021). Therefore, practitioners must define the impact categories etc. and the directions of influence in the goal and scope phase to avoid double counting. This reflects a general challenge in S-LCA, which currently lacks comprehensive reciprocal and multiple cause-effect relationships (Roche et al. 2026; Springer et al. 2020).

It can be concluded that S-LCA can be regarded as a technique with a focus on identifying the most relevant social hotspots out of many social topics, whereas social acceptance as a social topic, potentially having an impact on humans, itself.

4.3 Approaches beyond the literature

The systematic literature review showed that some authors integrate social acceptance into S-LCA (3.2.3) or vice versa (3.2.4), while others regard both topics as important but without drawing a clear connection between them (3.2.1, 3.2.2). In the following, additional approaches beyond those identified in the literature are discussed (4.3.1–4.3.4) and visualized in Fig. 8. Given the differing perspectives of the suggested approaches, the development of several frameworks appears to be appropriate. For now, each initial approach adds to the fundamentals of those frameworks that could be developed in the future. Nevertheless, certain limitations remain. The major hindrance so far are heterogenous terminologies, definitions and understandings used for social acceptance, but also for S-LCA. This is part of the third level of this research.

4.3.1 S-LCA as a communication tool for social acceptance analysis

An alternative to the approaches found in the literature is the integration of S-LCA into social acceptance and social acceptance analysis by using S-LCA results for communication (Approach 1). The results can be used strategically in

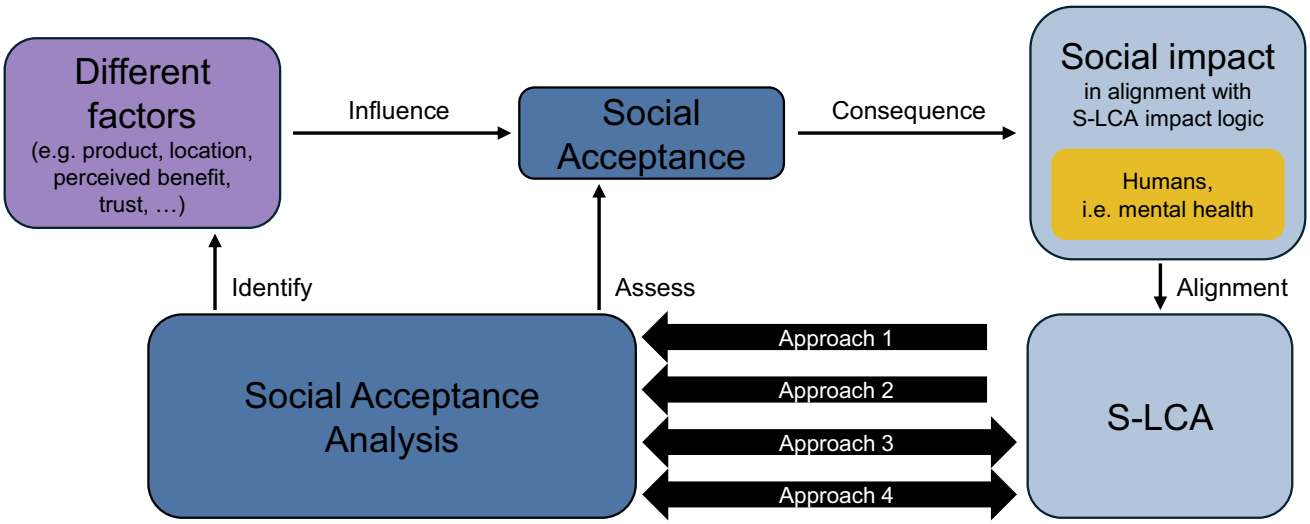

Fig. 8 Suggested approaches of combining S-LCA and social acceptance

the context of informative sessions or surveys, e.g., at an event such as a public forum where the local community is to be informed about a technology. In addition to technical data, economic aspects and environmental impacts, potential social impacts along the supply chain, the location itself as well as its end of life treatment, can be communicated though S-LCA results. The same applies to surveys, e.g., where technology information is provided in the survey followed by questions about their attitudes towards that technology.

On a more general level, S-LCA results can also enable individuals to independently access the information they need, by screening studies or reports. Nevertheless, this benefit is limited as S-LCA results are no common source of information and are often not easy to comprehend, especially for laypersons. In addition, S-LCA results can be biased or not publicly available for everyone. The provision of information through S-LCA should not be considered to increase social acceptance, but rather to enable individuals to form free opinions.

4.3.2 S-LCA as a secondary data source for social acceptance analysis

The second suggested approach is using S-LCA results as a secondary data source for social acceptance analysis. This could substitute parts of time-consuming social acceptance analysis with primary data collection, albeit potentially losing some accuracy.

This works only if the factors influencing social acceptance are known and are part of the S-LCA. Furthermore, their direction of effect must have been identified beforehand, e.g., a negative health impact is likely to impede social acceptance, whereas the aforementioned controversy of information about a technology might either increase or decrease a person's acceptance (see Sect. 4.1).

For example, a survey can be used to determine the social acceptance of a technology by the local community. If factors such as trust, proximity to the house, and health consequences due to air pollution were identified as influencing social acceptance, they must be assessed, e.g., using a questionnaire. Health impacts on the local community can be identified through S-LCA and may therefore provide insights into the potential social acceptance of people. This factor would then not need to be assessed separately in a questionnaire, which could be beneficial for the overall survey, as questionnaires should not be excessively long.

To what extent the social topics of S-LCA coincide with the factors that influence social acceptance depends on the goal of the study and the underlying data. If secondary data and predefined social indicators are available, they could serve as data sources, e.g., the following indicators from PSILCA (Hamed et al. 2025): *contribution to economic development* and *access to electricity* for the stakeholder group of society, the *sector average wage* for workers or *internally displaced people* for the local community.

This is similar for S-LCA studies conducted with primary data and individually established social impact categories etc. Whether this data can be used also depends on their alignment with the relevant factors. Furthermore, it should be considered whether only the foreground system or also the background system is covered, and if this corresponds to the scope of the social acceptance analysis.

This advantage might be impaired by the heterogenous focus of life cycle stages and stakeholder groups of S-LCA and social acceptance. For the former, mainly workers, the local community and society are addressed in a cradle to gate scope, whereas for social acceptance the local

community and consumers within the use phase are in the center of interest. Even though existing S-LCA subcategories can theoretically contain information of factors influencing social acceptance, the factors identified within this research do not directly coincide with existing impact categories etc. Therefore, it can be questioned whether S-LCA is capable of serving as a secondary data source in practical applications.

This suggested approach is aligned with findings of Hannouf et al. (2025), as described in Sect. 3.2.4. The authors state that S-LCA provides insights into where stakeholders should be included. Nevertheless, they follow a different approach, as the overall goal is the technology development which is socially acceptable and implementable to avoid potential burdens for the market introduction.

4.3.3 Joint primary data collection of S-LCA and social acceptance analysis

The third approach suggested is similar to the approach in Sect. 4.3.2, where S-LCA serves as a data source for social acceptance analysis. Likewise, a joint primary data collection could be feasible. For example, a stakeholder consultation in the form of a questionnaire or interviews could be used to gain knowledge about material impact categories, subcategories and indicators to be assessed in S-LCA as well as factors such as perceived risks, problem perception etc. for the analysis of social acceptance. If time can be saved by doing so, this could be advantageous.

It is a prerequisite again that the factors and their direction of effect are already known. If this is not the case, two separate assessments of S-LCA and social acceptance might be more beneficial to reduce the risk of losing accurateness. Moreover, a joint data collection is likely to become too big, as both topics themselves are complex.

4.3.4 Analysis of discrepancies of S-LCA and social acceptance analysis results

The fourth suggested approach to combine S-LCA and social acceptance analysis is to assess the discrepancy in their results without making a direct comparison between them. For example, if S-LCA results for the impact subcategory “Safe and healthy living conditions” for the local community are determined as having a low impact and the perceived risk of the local community for their living conditions due to a certain technology is high, questions about the reasons for the discrepancy can be raised and communication can be targeted to that discrepancy. Besides, it can add to the understanding of how acceptance is formed.

This approach is also subject to the limitation that the results of S-LCA and social acceptance may differ in terms of their definition, e.g., the terminology of impact categories vs. factors influencing social acceptance. Moreover, the results need to apply to the same stakeholders, which, as outlined above, may not necessarily be the case.

5 Conclusion

This article provides meaningful fundamentals for the combination of S-LCA and social acceptance. This includes a comparison of their main characteristics as well as an analysis of the practically implemented integrations described in the literature. The discussion presents the conceptualization of social acceptance and, furthermore, suggests approaches for integration beyond those identified in the literature. Moreover, it highlights both the challenges and opportunities of their combination, while also considering the alternative of keeping them separate. Together, these insights form the fundamentals for the development of frameworks that should be extended in the future.

The major difference between S-LCA and social acceptance is that S-LCA is a technique that follows a methodological framework whereas social acceptance is a response by humans, i.e. an attitude, intention or behavior, without a distinct definition and methodology. It only becomes a technique through its analysis. The focus of S-LCA lies on the identification of the most relevant social impacts out of many social topics, whereas within social acceptance analysis the social acceptance of humans is identified by assessing the factors influencing it. Their differences become also evident by means of their perspectives: S-LCA is centered on social impacts on stakeholders, whereas the assessment of social acceptance for a technology is mostly focused on the market implementation, being an economic impact. S-LCA follows a life cycle perspective which is not the case for social acceptance analysis. Nevertheless, the logical foundations also reveal that they share aspects of their goals and purpose, e.g., both can be used for development, decision-making, or communication of environmentally and socially sound technologies. Hence, a methodological coherent integration of both can offer significant advantages for a sustainably sound and socially accepted technology.

The number of published articles is moderately rising but remains at an overall low level. The majority of publications were conducted within Europe, even though the topics of S-LCA and social acceptance are analyzed internationally. All publications addressing an impact assessment include reference scales while impact pathways are not used. Most articles address the construction and wastewater sector; however, the overall sectors show a degree of variance. This is not the case when it comes to scientific journals, where the articles were published. All of them have a focus on

environmental, chemical, resource topics etc. Among the results, there is no journal specifically devoted to social science. This is in line with the author's affiliations, which might not, according to the names of these affiliations, hold a focus on social science. If this is the case, it could be a drawback, as interdisciplinary expertise is indispensable while combining S-LCA and social acceptance.

In the literature the relationship between S-LCA and social acceptance is handled differently. While some authors address both topics but do not draw a line between them, others do make a connection but without further elaboration. A third group of authors suggests specific ways to integrate social acceptance into S-LCA by creating new impact categories, subcategories and indicators and one publications states S-LCA as helpful to identify stages during development, where stakeholder should be involved to add to their acceptance. Their understanding of social acceptance, where stated, is either as a social impact on humans or as an impact on technology. In this research the former interpretation is defined to be in line with the logic of S-LCA, since the integration of human actors constitutes its central focus. In contrast, the understanding of social acceptance as an impact on a company arises from the circumstances that market implementation may depend on it. This interpretation would not correspond to the classical logic of S-LCA. It appears that some authors assume that more knowledge about social impacts automatically results in greater social acceptance, which however, is not universally valid. Two publications make the statement that S-LCA and social acceptance are not connected yet.

These results are limited by the fact that publications might have been left out during the systematic literature review. This is due to the divergent terminology used around the research of social acceptance.

The interpretation of social acceptance for this research is considered as being a response, attitude or behavior, which can have a mental social impact on humans. Therefore, it is suggested to implement the impact category "social acceptance" in S-LCA. Subcategories and indicators are to be chosen dependent on the product system, as the social acceptance and the factors influencing it are individual. This requires that the factors and their direction of action are known. Whenever possible, social acceptance should be integrated in more than one life cycle stage, even though data gathering might be a major challenge. Clarifying who belongs to certain stakeholders and which indicators and subcategories are considered to add to which impact category is crucial, especially if S-LCA and social acceptance are combined, to avoid double counting and misunderstandings as the terminology used to refer to the stakeholders is not consistent. The absence of a clear statement on the creation of subcategories and indicators in this study may be regarded as a limitation. This, however, is due to the multitude of factors and their individual characteristics.

Social acceptance may not only be integrated into S-LCA as done so far, but also vice versa. One suggested approach is to use S-LCA as a communication tool providing information for social acceptance analysis. This creates the opportunity for individuals to form a free opinion of social acceptance on the one side, even though it can be hard to comprehend on the other. It may either be deployed selectively, e.g., in information sessions or surveys or to empower individuals to seek out relevant information independently. However, it is not a common source of information, especially for layperson, and not always publicly available. While science used to receive a high level of trust in the past it is becoming increasingly difficult to build arguments on the basis of scientific findings.

Another option is to use S-LCA results as a secondary data source to analyze social acceptance, if the scope of the assessment regarding life cycle stages and stakeholders is compatible and the factors which influence social acceptance as well as their direction of effect are known.

A further option for a mutual inclusion is to combine the primary data collection or to assess the discrepancy between their results. Conversely, information might get lost through the combination and it might go along with the risk of double counting.

Even though it may be advantageous to conduct the S-LCA and the analysis of social acceptance in parallel rather than combining them, as the individual results are already useful and their integration could entail a loss of detail, a coherent methodological integration is recommended. The mental impact on humans resulting from their social acceptance level for a certain technology aligns with the S-LCA impact logic and expands the view of social impacts, especially those of psychological nature. Nevertheless, this suggested approach may encounter difficulties, for example due to the requirement that factors influencing social acceptance must be known. So far, only minor statements about the different handlings of S-LCIA and S-LCPA are made and represents a major research need for the future.

In summary, the findings suggest that S-LCA and social acceptance could go hand in hand. For example, they could be combined to generate a benefit for one or the other, especially in terms of data provision and generating an overview of social aspects. Prior to that, it is essential to precisely define social acceptance as well as to identify the specific factors influencing the object of study. How the fundamentals of this research can be translated into practically applicable and feasible frameworks requires further investigations. This should include potential bottlenecks and further constraints. Moreover, the need for additional exploratory approaches remains, in which the conceptualization of

social acceptance in S-LCA is addressed, e.g., in relation to different S-LCA types, technological product systems, etc. Another research need is the exchange of expertise between S-LCA and social acceptance, particularly by integrating knowledge from social science. This shows that, overall, significant room for development remains, which will be addressed in a follow-up study.

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Data availability All data generated or analyzed during this study can be found in this published article and its supplementary information.

Declarations

Competing interests The authors declare no competing interests.

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