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Contributions to the sustainable development goals in life cycle sustainability assessment: Insights from the Handprint research project

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Abstract
The United Nations' Sustainable Development Goals (SDGs) represent consensual, global scale targets, encouraging not only the fight against unsustainable aspects in society (e.g., poverty or hunger) but also positive contributions to sustainable development (e.g., renewable energy use or human well-being). The SDGs are, however, not per se designed as a performance measurement system for businesses and products. Consequently, research is challenged to develop convincing approaches and indicator systems that capture how businesses contribute to the SDGs.

Against this background, the Handprint approach was developed. This paper documents methodological developments of a respective research project and extends the focus from reducing unsustainable, negative business practices toward striving for positive contributions to sustainable development in sustainability assessment and management. We first summarize the status quo of assessing positive contributions to sustainable development in research and practice. While a "Footprint" approach primarily measures negative environmental and/or social impacts, the "Handprint" approach focuses on positive contributions to sustainable development. Second, we illustrate and prioritize core assessment categories and indicators. Third, we describe how a sustainability assessment approach to evaluate positive contributions to sustainable development at the product level was developed and demonstrate its feasibility in a pilot case study.

Keywords Handprint · Life cycle sustainability assessment · Sustainable development goals · Product sustainability assessment · Multi-method approach · Fuzzy set theory

1 Introduction

Sustainability management research and practice increasingly incorporate integrated life cycle thinking (Guenther and Schneidewind 2017; Rieckhof 2017) to assess the environmental, economic, and social damages and benefits along product life cycles and corporate supply chains (e.g., Blass and Corbett 2018; Di Cesare et al. 2018; Ekener et al. 2018; Maas et al. 2016; Schaltegger and Burritt 2006). Following the prevalent definition of sustainability "to meet the needs and aspirations of the present without compromising the ability to meet those of the future" (WCED

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1987, p. 39) and common operationalization in management and research (Bansal 2005; Baumgartner and Ebner 2010; Reisch et al. 2013; Schaltegger and Burritt 2005), this paper differentiates social (including human health and ethics), environmental as well as economic sustainability. The latter is extended to specifically include governance and institutional aspects (Toumi et al. 2017). So far, however, life cycle thinking in sustainability management research has often focused on becoming less unsustainable instead of assessing positive contributions to sustainable development (Hacking and Guthrie 2008; Sala et al. 2013a). George (2001) argues that a focus on solely mitigating negative sustainability problems is an important objective, but lacks ambition resulting in only marginal contributions to sustainable development. Therefore, Sala et al. (2013b) posit that life cycle sustainability assessment (LCSA) "should be shifted from avoiding negative impacts to also proactively enhancing positive impacts" (p. 1666). A shift from assessing negative outcomes to societal and environmental benefits would contribute to recognizing and realizing win-win opportunities for business and society (Di Cesare et al. 2018). Such win-win opportunities can be achieved by a product responsibility approach that moves from minimizing harm to additionally creating positive sustainability benefits (e. g., the restoration of nature; Rost 2015).

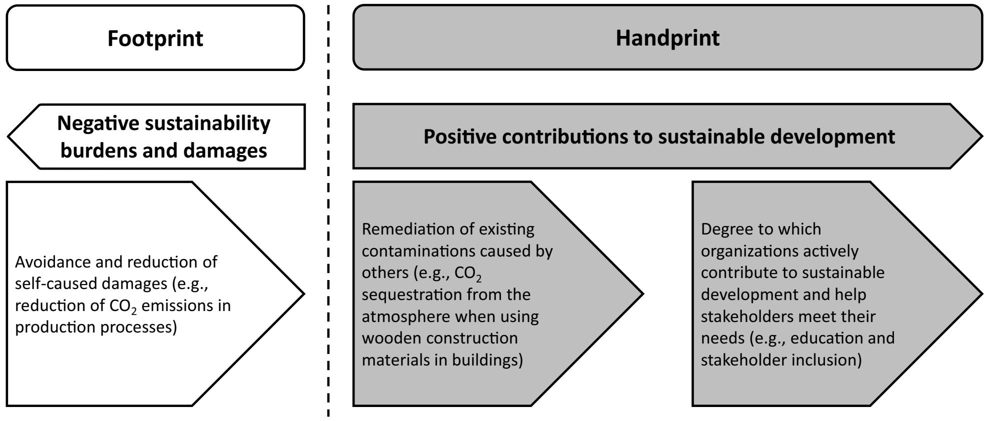
Currently, however, the existing scientific literature largely neglects positive contributions to sustainable development. While a number of researchers relate positive aspects to the social dimension (e. g., Ekener et al. 2018; Kroeger and Weber 2015), potential positive economic and environmental aspects are barely covered. Furthermore, there is no consensus on what generally constitutes a positive contribution to sustainable development (Ekener et al. 2018), but the need for further investigation has been identified (Silva and Guenther 2018). Di Cesare et al. (2018) as well as Eberle and Schmid (2016) suggest the United Nations' (UN 2015) Sustainable Development Goals (SDGs) as a suitable and universal reference framework for capturing contributions to sustainable development. The SDGs encourage not only the fight against unsustainable aspects in society (e. g., poverty or hunger) but also positive contributions to sustainable development (e. g., promotion of renewable energy use or human well-being; UN 2015; Verboven and Vanherck 2016). Although the SDGs represent consensual targets on a global scale when pursuing positive contributions to sustainable development (Schaubroeck and Rugani 2017), they are not per se designed to evaluate contributions at organizational or product level (Kühnen and Hahn 2017). Furthermore, the SDGs mostly provide vague, imprecise, and thus, "fuzzy" (Zadeh 1965) criteria to judge contributions to sustainable development (Verboven and Vanherck 2016). For example, SDG 10.2 fuzzily demands "By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status" without being in any way specific how businesses can contribute to and measure such an empowerment and promotion. Consequently, research is challenged to develop convincing approaches and indicator systems that capture how businesses and their products potentially contribute to the SDGs (Verboven and Vanherck 2016).

Another frequently discussed issue in the field of LCSA relates to the differing maturity levels of the different elements of LCSA (e. g., Corona et al. 2017; Kloepffer 2008). LCSA has significantly advanced in the environmental dimension since the International Standardization Organization (ISO) published the first 14040 standard series in 1997 on environmental life cycle assessment (ELCA) of products (reviewed and further developed in 2006; ISO 2006). However, despite the publication of a standardized framework, "it leaves much to interpretation" (Curran 2013, p. 273). Early notable efforts to assess sustainability holistically at the product level include, for example, the product sustainability assessment approach (PROSA) by Grießhammer et al. (2007) or the SEEBALANCE approach developed by BASF (Saling 2017). However, Arcese et al. (2016) conclude that none of these early approaches reached a consensual predominance over the others, so that the field has become fragmented.

Furthermore, in contrast to the product level focus of ELCA, research on life cycle costing (LCC) and social life cycle assessment (SLCA) often relates economic and social aspects to the organizational level (e. g., Burritt and Schaltegger 2014; Dreyer et al. 2006; Martínez-Blanco et al. 2015). Consequently, the assessment of economic and social sustainability at the product level remains at a developmental stage (Finkbeiner et al. 2010; Fontes et al. 2018). Thus, the overall field of LCSA is incomplete as it fails to address positive contributions to the SDGs, as well as imbalanced in terms of integrating the three sustainability dimensions at the product level. Triggered by the incompleteness and imbalance of the LCSA field, a group of researchers initiated the Handprint research project in 2013. The Handprint approach addresses positive contributions to sustainable development, whereas the established footprint (e. g., Wackernagel and Rees 1996) approaches primarily measure negative environmental and/or social impacts. While footprint approaches, such as environmental footprint, carbon footprint or water footprint, all present relevant and necessary research with its own strengths, the focus of this work is on positive contributions to the SDGs rather than reducing and avoiding self-caused damages. Fig. 1 illustrates the rationale of the Handprint compared to the rationale of established footprint approaches.

This paper presents the methodological steps of the research project, describes the Handprint assessment and

Fig. 1 Rationale of the Handprint



evaluation approach, and discusses its key contributions. Thus, the assessment and evaluation of positive contributions to the SDGs was put into practice. Overall, the Handprint aims at contributing to the field of LCSA by providing an assessment approach that is consistent with the established standardized framework of conducting ELCA as outlined in ISO 14040 and 14044 (i.e., goal and scope definition, inventory analysis, impact assessment, and interpretation). Furthermore, a contribution to the field lies in shifting the established focus from primarily considering negative aspects toward integrating positive aspects as well. Overall, the research aims of the Handprint project included:

1. Reviewing the assessment of positive contributions to sustainable development in research and business practice.
2. Identifying positive sustainability indicators.
3. Developing an evaluation approach that expresses relations between the selected indicators and positive contributions to sustainable development.
4. Testing and validating the Handprint approach in case studies.
5. Sharing the project insights with business practitioners, scholars, political actors, and non-governmental organizations.

2 Methodological steps of the research project

The Handprint project was based on a multi-method approach (Burks and Krupka 2012; Zellmer-Bruhn and Gibson 2006) to develop a comprehensive and practically feasible method for assessing and evaluating a product's positive contributions to sustainable development. The core research question was: 'What positive sustainability contributions occur throughout the life cycle of a product and how can they be assessed and evaluated'. Fig. 2 displays the individual research steps of the multi-method approach, describes the actions taken, and shows the interim-results. The approach involved reviews of the existing literature, corporate practice, and external reference frameworks. The combination of several systematic analyses created a comprehensive and broad overview of the status quo in the sustainability assessment field. The insights from the reviews of literature and practice formed the starting point for the development of the Handprint approach.

The reviews were followed by a two-pronged Delphi study and accompanied by stakeholder workshops. The Delphi study and stakeholder workshops offered a platform for the consideration of different expert claims and opinions for the development of the Handprint approach. The multi-method approach included constant feedback from external stakeholders to support the development of a scientifically sound and practice-oriented assessment approach. This also highlights the iterative approach of the project. Finally, the Handprint approach was tested and validated in case studies (some were still ongoing at the time of writing). The following sections document the individual steps of the multi-method approach.

2.1 Systematic literature review

The systematic review of academic literature dealing with sustainability assessment and measurement provided the foundation for the further research steps (for an extensive overview see Kühnen and Hahn 2017, 2018b). It followed the research approaches suggested by Denyer and Tranfield (2009) and Tranfield et al. (2003). The three-step process included preparation of the review, conducting the analysis as well as concluding and sharing the results (Tranfield et al. 2003). The results provide an overview of various sustainability assessment methods at the company and product level, an analysis of the scholarly understanding of positive contributions to sustainable development, and a first extraction of indicators that claim to capture positive contributions

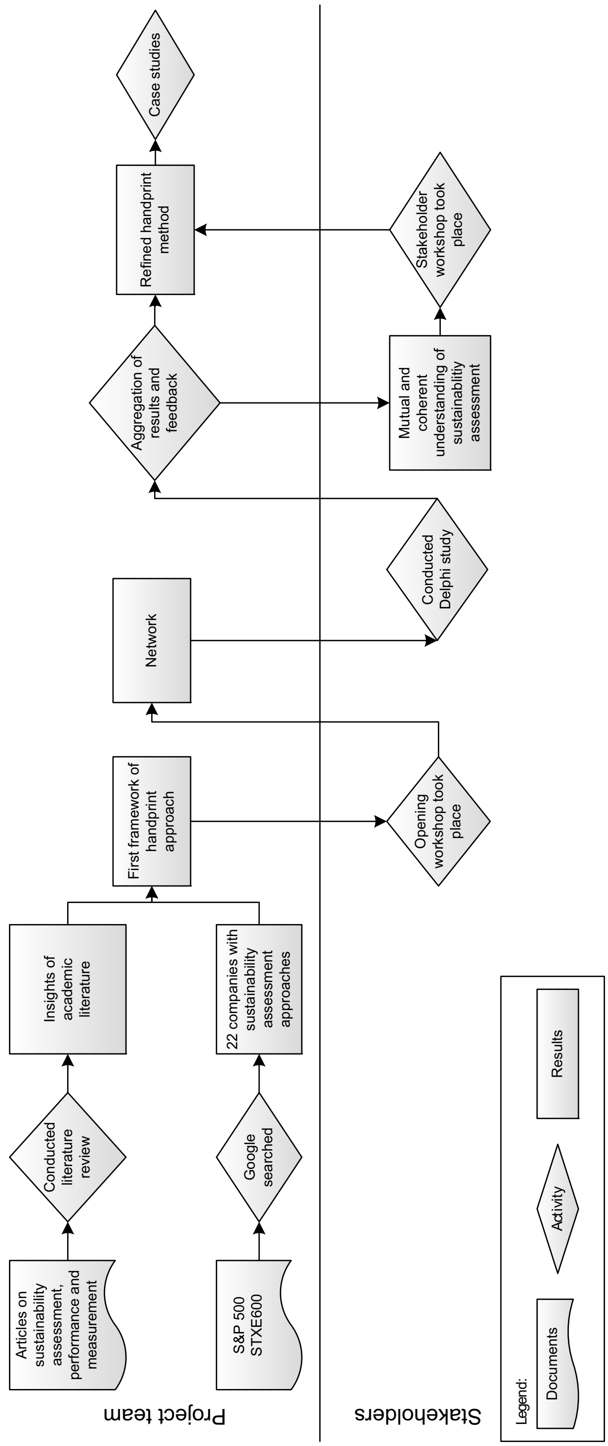


Fig. 2 Overview of the multi-method approach

to the social dimension of sustainability (and occasionally to the environmental and economic dimensions as well).

Because researchers argue that positive contributions to sustainable development mainly result from the social dimension of sustainability (e. g., Kühnen and Hahn 2018a; Schaubroeck and Rugani 2017), the systematic literature review started with an extensive keyword search of sustainability assessment articles dealing with positive benefits to human well-being (i. e., the social dimension) along product life cycles and corporate supply chains. As sources for identifying the literature, two major databases were selected (i. e., the Social Science Citation Index and the EBSCO Business Source Premier databases) because of their extensive coverage of English peer-reviewed journals in business, management, and accounting. We conducted an extensive keyword search to find relevant articles published in a period with an open beginning up to the end of 2015. To locate relevant articles, the search revolved around the key search terms and wildcards soci*, sustainab*, integrat*, responsib*, CSR, TBL, or "triple bottom line" (to locate articles on the social dimension in sustainability assessment), "life cycle" or "supply chain" (to ensure a life cycle orientation beyond isolated organizational boundaries), and assess*, analy*, account*, quanti*, indicator*, index, indices, measur*, metric*, or criteria (to locate articles about performance measurement, assessment, and accounting). Following the initial search, each article was screened to assess its relevance. In the end, the search process resulted in 141 papers with substantial relevance to social indicators for life cycle-oriented sustainability assessment (for a detailed overview of the manual relevance-screening process and the number of articles resulting from each search term and database see Kühnen and Hahn 2017, 2018b).

2.2 Review of sustainability assessment approaches in companies and external reference frameworks

In addition to the systematic review of academic literature, an analysis of sustainability assessment methods from corporate practice was conducted to investigate if there are any prominent approaches to capture and assess positive contributions to sustainable development. For this practice review, the research approach for conducting a systematic literature review suggested by Denyer and Tranfield (2009) was adapted. To identify cases from corporate practice, companies listed in the Standard & Poor's 500 (S&P 500) and Stoxx Europe 600 (STXE 600) indices (as of 30 January 2015) were reviewed to reveal if any of those companies developed their own proprietary sustainability assessment approaches. 22 sustainability assessment approaches from corporate practice were identified. All of these companies publicly claimed to use a sustainability assessment approach that integrates social, environmental, and economic indicators. These approaches applied in corporate practice were analyzed in terms of the development of indicators that address positive contributions to sustainable development.

To complement the systematic review of research and practice, external reference frameworks were additionally reviewed: Particularly, the UN (2015) SDGs, the ISO (2006) 14040 standard series on ELCA, the guidelines and methodological sheets for SLCA published by the United Nations Environment Programme and Society of Environmental Toxicology and Chemistry (UNEP and SETAC 2009, 2013), the Vision 2050 framework by the World Business Council for Sustainable Development (2010), the better life index and green growth initiative by the Organisation for Economic Co-operation and Development (OECD 2017a, 2017b), the Economics of Ecosystems of Biodiversity (2017), and the World Resources Institute (2012) report on corporate ecosystems services. Reviewing and evaluating these frameworks provided guidance for the research project in terms designing the Handprint approach. Particularly, the established ISO framework for conducting environmental and social life cycle assessment was adopted to ensure the general methodological soundness of the Handprint approach, whereas the UN SDGs were selected as globally consensual reference to evaluate positive contributions to sustainable development.

2.3 Delphi study

To complement and advance the insights of the systematic review of academic literature and corporate practice (yielding a first extraction of indicators that aim at capturing and assessing positive contributions to sustainability), a two-pronged Delphi study (i. e., consisting of two parallel Delphi inquiries) with experts in the field of life cycle assessments was conducted (for an extensive overview see Kühnen and Hahn 2018a). In the two parallel inquiries, the aim was to achieve a comprehensive and coherent understanding of relevant (1) social aspects and (2) positive sustainability aspects (thus, addressing all sustainability dimensions beyond social aspects) to be considered in product sustainability assessment. In general, the Delphi method aims at structuring a group communication process in which a group of individuals deals with a complex problem. It is an anonymous, iterative multi-round survey process, in which the moderator provides feedback of the group opinion to the participants after each round (Linstone et al. 2002). Schmidt (1997) outlines a structured approach of the implementation of a Delphi study, which was applied in the research project.

For both parallel Delphi inquiries on social and positive sustainability assessment, the same pool of experts from academia, corporate practice, and civil society with substantial experience in life cycle assessment, sustainability assessment, and sustainability was invited to participate. The two parallel inquiries followed the same procedure. The first round started with open qualitative questions asking what the most important aspects, criteria, and indicators for measuring social and positive sustainability performance along product life cycles and corporate supply chains are. After this brainstorming round, qualitative content analysis (Mayring 2010) was used to inductively (Seuring and Gold 2012) evaluate and code the open survey responses into recurring aspects. The open responses were consolidated into a list of several items (i. e., aspects to consider when assessing social and positive sustainability performance). In the second round, the experts quantitatively rated the importance of each item. Subsequently, the ratings of each respondent were aggregated into a group response. For the third and final round, the participants were provided with aggregated group responses to reflect the group opinion, and then, to finalize their rating of each item. Overall, the two-pronged Delphi approach achieved a coherent understanding and prioritization of the core overarching categories as well as concrete indicators for the assessment of social and positive sustainability.

2.4 Stakeholder-workshops

Throughout the project, stakeholder workshops were conducted with external stakeholders (these experts were not part of Delphi surveys) to present the status of the project to experts and receive iterative feedback. The discussions with the stakeholders revealed how companies—aware and unaware—already dealt with positive sustainability effects and their assessment. Furthermore, the stakeholders described their expectations of the Handprint approach and provided critical reflections based on personal experience. In addition, a number of subject matter experts (external to the project and not part of the pool of experts in Delphi approach) critically reviewed the development of the handprint project and provided valuable feedback that was included in the further developments after each workshop. Table 1 presents an overview of the five stakeholder workshops, which were held between 2015 and 2017.

2.5 Deductive systematization of the indicators for the handprint approach

The reviews and Delphi inquires yielded an abundance of potentially suitable indicators as the literature contributions, practice cases, and the Delphi experts were eager to propose their own diverse and fragmented indicators and assessment approaches (for an extensive overview of the various indicators used in research see Kühnen and Hahn 2017, 2018b; for an overview of the various indicators used in business practice see section 3.1 and Table 2; for detailed implications from the Delphi inquiries see Kühnen and Hahn 2018a). As a first step to systematize the indicators, we allocated the high-level performance aspects and concrete indicators (from the literature and practice review, and from the Delphi study) to the three dimensions of sustainability by conducting a deductive (Seuring and Gold 2012) content-analysis (Mayring 2010) approach. Deduction requires choosing ex ante existing conceptual framework as a lens for analyzing the data to arrive at plausible findings (Seuring and Gold 2012; Timmermans and Tavory 2012). Employing this deductive logic in this research project, we chose the typical sustainability dimensions present in various definition and frameworks as the analytical lens. Consequently, we assigned the indicators from the literature and practice review, and from the Delphi study to the social, environmental, and economic (including governance and institutional aspects) dimensions of sustainability. After allocating the abundance of indicators to the sustainability dimensions, the project team selected and prioritized the specific indicators and metrics in iterative internal discussions using the SMART (Doran 1981) indicator selection criteria to design the Handprint approach. These design and selection criteria propose that indicators need to be specific, measurable, assignable, realistic, and time-related (i.e., SMART).

Regarding the aspect of being specific (i.e., targeting a specific area for improvement), we selected indicators that clearly reflect businesses' potential influence on contributing to the SDGs. In terms of being measureable (i.e., quan-

Table 1 Overview of stakeholder workshops

Workshops	Workshop 1	Workshop 2	Workshop 3	Workshop 4	Workshop 5
Topic	Kick-off: Presenting the planned approach of the research project and understanding stakeholders' expectations	Introducing and reviewing the current status	Presentation of framework methodology with focus on SDGs as evaluation reference	Introducing the handprint concept; discussion of application fields (e.g., accounting)	Reviewing the fuzzy set approach and specific indicators
Time	5 November 2015; full day workshop	31 May 2016; half day workshop as part of a conference	1 June 2016; full day workshop	23 September 2016; half day workshop as part of a conference	9 November 2017; full day workshop
Location	Berlin, Germany	Wuppertal, Germany	Wuppertal, Germany	Lüneburg, Germany	Wuppertal, Germany
Attendees	29 attendees including experts from academia, policy, practice, non-governmental organizations	32 attendees, mainly with a practical and academic background	50 attendees from practice, including representatives of specific industries such as bio-technology, but also representatives of the United Nations working on the SDGs	20 subject matter experts on measuring sustainability and sustainability accounting	5 subject matter experts from practice on sustainability assessment

tifying or at least suggesting an indicator of progress), we selected qualitative and (semi)quantitative indicators that are suitable to capture progress toward the SDGs over time. Furthermore, we selected indicators that are assignable (i. e., specifying who will be responsible for results) to the responsibility of businesses organizations. Therefore, we also selected realistic (i. e., stating what results can realistically be achieved with given resources) indicators that establish a realistic relationship between organizational actions (not national actions) and sustainable development. Finally, regarding the aspect of being time-related (i. e., specifying when results can be achieved), we selected indicators that are suitable for conducting periodic (e. g., annually) assessments to regularly show organizational contributions to the 2030 Agenda for Sustainable Development.

3 Results

3.1 Analysis and synthesis of the systematic review of research and practice on assessing positive contributions to sustainable development

The systematic review of the academic literature revealed a limited number of publications explicitly dealing with positive contributions to sustainable development. A few early references in the sustainability assessment field criticize management scholars' and practitioners' ambition to deliver positive contributions to sustainable development (George 2001) for their negative perspective on sustainable development (e. g., as a necessary and costly evil to maintain legitimacy; Hart and Milstein 2003). From 2005, first noticeable contributions introduce the conceptual foundation of positive contributions and benefits into sustainability assessment research. Norris (2006) develops and demonstrates the methodology of a life cycle attribute assessment to estimate the potential health benefits resulting from economic activities. Benoît et al. (2010) emphasize that positive benefits can play a major role in SLCA, compared to their marginal role in current ELCA. Several authors suggest generic aspects to assess positive sustainability benefits including the promotion of biophysical system integrity (Gibson 2013), regeneration of the environment (Pauw et al. 2014), promotion of a circular economy (Haupt et al. 2017), and the functional value of products to contribute to human well-being (Schaubroeck and Rugani 2017). Some authors even propose more concrete frameworks and indicators that aim at delivering a positive transition to sustainability. Neugebauer et al. (2014) elaborate on a cause-effect relation between the payment of fair wages and the level of education, which positively or negatively affect human well-being. While Schaltegger et al. (2016) state that a sustainability transformation of organizations, consumption patterns and life-styles is a key positive contribution of sustainable entrepreneurs to sustainable development, which needs to be driven by business model innovation, Schaltegger and Burritt (2014) propose indicators of efficiency, consistency, and sufficiency to contribute to a positive sustainability transformation of markets and society.

In terms of empirical experience and case study research, a few researchers provide empirical insights into positive sustainability benefits of airbags (Baumann et al. 2013), laptop computers (Ekener-Petersen and Moberg 2013), mobile phones (Wilhelm et al. 2015), and solar power generation (Corona et al. 2017). Ekener et al. (2018) investigate the possibilities of addressing positive impacts in SLCA using the case of vehicle fuels. They emphasize problems in determining what should be counted as a positive impact. Correspondingly, Hacking and Guthrie (2008) conclude that deciding whether sustainability impacts are positive or negative is problematic, since such decisions often involve subjective value judgments. In turn, this problem underlines the importance of a globally consensual reference framework such as the SDGs. In this context, Schaltegger et al. (2018) propose that sustainable entrepreneurship as a constructive approach aiming to transform markets and society could be inspired by the SDGs and use them as orientation for collaborative entrepreneurial ventures.

Overall, despite a few notable efforts to describe positive contributions to sustainable development, a clear definition or joint understanding of what constitutes positive contributions to sustainable development is missing in the existing literature. In contrast to the limited findings in the academic literature, the systematic review of business practice revealed that the majority of the 22 identified practice cases claim to integrate positive benefits aspects into sustainability performance measurement. Table 2 provides an overview of the identified 22 companies including the respective indicators used to assess positive contributions to sustainable development.

Although the validity of the specific indicators used can be criticized for being overly generic, this points to the increasing importance of assessing positive contributions to sustainable development in business practice. Furthermore, the results of the systematic practice review point to significant inconsistencies in the use of positive indicators due to the lack of suitable standardized frameworks that guide and prioritize the selection of positive sustainability indicators.

3.2 Findings and implications from the Delphi study: General prioritization of social and positive sustainability aspects

The results from the analysis and synthesis of the systematic literature and practice review point to the increasing importance of assessing social and positive sustainability

Table 2 Overview of indicators used in business practice to assess positive contributions to sustainable development

Company name and designation of sustainability performance measurement approach	Identification via share indices	Indicators used in business practice to assess positive contributions to sustainable development
3M Company—Life Cycle Matrix	S&P 500	Selection of hard goods components that meet high safety performance standards; customer training programs for safe and effective product use; installation of safety devices
Clorox Company—Preferred Ingredient Calculator	S&P 500	Transparency and product information (e.g., on the appropriate use, storage and disposal); animal welfare and pet safety
Colgate-Palmolive—Product Sustainability Scorecard	S&P 500	Responsible sourcing and raw materials
Delphi Automotive—Manufacturing Capability Assessment	S&P 500	Existence of a documented process for ensuring health and safety (H&S) of all employees at suppliers; process audited in compliance with all applicable requirements, including an emergency plan; health and safety related information tracked and communicated throughout the organization on a regular basis
Dow Chemical—Sustainability Footprint Tool	S&P 500	Improved biodiversity; access to telephone networks and the internet; access to (renewable) electricity; access to markets including improved transportation infrastructure: use of the product must be relevant to the needs of the citizens of emerging economies; cost of the product must be affordable (not prohibitively expensive); life cycle knowledge (extent of current knowledge to list the main operational stages of the life cycle); value chain process safety; potential to address world challenges (healthier drinking water, affordable housing; improved food production; improved personal/public health; improved (end user) safety)
Food Machinery Corporation (FMC)—Sustainability Assessment Tool	S&P 500	Human health promotion
Ford—Product Sustainability Index	S&P 500	Mobility capability (luggage compartment volume plus weighted number of seats related to vehicle size) to support life in crowded cities; affordability (life cycle ownership costs); safety
Johnson & Johnson—Earthwards	S&P 500	Use of fair-trade materials; selection of socially responsible suppliers; supporting causes with clear social benefit
Marriott International—Supplier Sustainability Assessment Program (MSAP)	S&P 500	Selection and development of socially responsible suppliers; fair labor and human rights practices
Procter & Gamble—Product Sustainability Assessment Tool	S&P 500	Creation of alternative ways to meet needs; time gains; ingredient specific safety; economic consumer benefit; social responsibility along the supply chain (compliance with international vendor assessment system); sustainable product use instructions; donation of patents; health benefits; job creation
Starbucks Coffee Company—Coffee and Farmer Equity (C.A.F.E.) Scorecard	S&P 500	Workers' access to housing, potable Water, and sanitary facilities; workers' access to education; worker safety and training; provision of personal protective equipment; workers' access to medical care; wages and related benefits; freedom of association and collective bargaining
Target Corporation—Sustainable Product Standard	S&P 500	Transparency of product labeling
Wal-Mart—Sustainability Index	S&P 500	Cooperation of suppliers with further upstream suppliers concerning social issues and documentation corrections and improvements; suppliers' local community development activities; existence of a social compliance management system at suppliers; knowledge about the location of facilities throughout the supply chain
Alcatel-Lucent—Sustainability Impact Analysis	STXE 600	[No indicators addressing positive contributions to sustainable development included]

performance along product life cycles and corporate supply chains. However, assessing social performance is still at a developmental stage, while assessing positive contributions to sustainable development at the organizational or product level currently lacks a sound conceptual and theoretical characterization of what constitutes positive contributions to sustainable development beyond the mere reduction of negative sustainability burdens and damages (Küh-

Table 2 (Continued)

Company name and designation of sustainability performance measurement approach	Identification via share indices	Indicators used in business practice to assess positive contributions to sustainable development
BASF—SEEbalance	STXE 600	Extra product-benefits that enhance customer satisfaction (e. g., service, increase in leisure time, low noise); fair trade labels; imports from developing countries; completeness and quality of product information (about origin, ingredients, use, potential dangers, side-effects, etc.); consumer labels; number of trainees; expenditures for professional training and continuing education; product-benefits for disadvantaged people (e. g., disabled, sick, poor) due to product qualities; wages and salaries; company expenditures for family support; company expenditures for social security; company benefits such as housing subsidies, workforce facilities, payments in kind and cafeteria subsidies; number of employees; number of unskilled workers (qualification of employees); number of female managers; number of disabled employees; expenditures for research and development
Bayer—Sustainability Check	STXE 600	Product value for society; employee safety; customer and consumer safety; public acceptance of the product
Berkeley Group—Social Sustainability Framework	STXE 600	Local facilities (about having access to the facilities people need for health, education and a social life); community space (about the design and management of public space and providing community facilities when it is appropriate); transport links (about helping people travel easily and sustainably); local integration (about connections to the surrounding area and ways to encourage social interaction); street layout (about creating places that are easy to move around and navigate); adaptable space (about creating public space that can be used flexibly now and could change easily in future); ability to influence (about whether people feel they can really affect decisions about their neighborhood, if they choose to get involved); local identity (about creating a place where people feel like they belong and where they hope to stay); links with neighbors (about creating a place where people know their neighbors and trust each other); wellbeing (about people's experiences and their life satisfaction); feelings of safety (about whether crime is low and residents feel safe both during the day and at night); willingness to act (about creating a community in which people work together to manage and improve the neighborhood); distinctive character (about creating a place that feels unique)
Deutsche Telekom—Sustainability Compass	STXE 600	Contribution of the product to the guarantee and enhancement of free access to information; product quality (fitness for use, ease of use); universal use of devices (standardization of connections and software); guarantee of data protection and protection of private sphere when using the product; support of socially acceptable use of the product; contribution of the product to the improvement of living conditions of the individual and/or general public (health, well-being, educational opportunities, nationwide broadband provision); contribution of the product to the improvement of work and life balance, social cohesion, cultural diversity, democratic processes and institutions; contribution of the product to the promotion of equal rights, equal opportunities, personal opportunities of the individual; product designed to cover basic human needs and/or needs that benefit society as a whole; adherence to the company's social charter throughout the entire value-added chain including suppliers (fundamental right to freedom of association, adequate remuneration, minimum standards in employment and health protection, prohibition of exploitative child labor); quality and accessibility of customer service; customer information (on charges for services and possible subsequent costs, product information on devices, adoption of common labels, labeling for constituents, recyclability, energy efficiency); communication of protective measures (measures for minimizing radiation exposure, government health warning for mobile phone usage by children, warning for mobile phone products with loud ring tones); socially acceptable marketing (fair and credible in accordance with the sustainability strategy, no exploitation of emergencies or customers that are not fully able to make decisions for themselves, e. g., children); product tailored to customers with special needs (e. g., senior citizens, or disabled persons), contribution of the product to long-term job creation
Henkel—Sustainability Master	STXE 600	Functional product performance; ease of use, product longevity; fairly sourced or certified ingredients; affordability; skin compatibility; consumer health and safety; health and safety of workers and value chain partners; job creation
SABMiller—Sustainability Assessment Matrix	STXE 600	Number of retailers engaged on responsibility; training days per employee; percentage of employees who have received alcohol responsibility training; percentage of female executives and managers (diversity and equal opportunity); corporate social investment spending breakdown; percentage of employees covered by trade unions and collective bargaining agreements
Solvay—Sustainable Portfolio Management	STXE 600	Healthy nutrition; availability of food; medical care; product safety throughout its entire lifecycle
Unilever—Brand Imprint	STXE 600	Nutritional value of products and nutritional information; food safety; hygiene improvements

Table 3 Prioritization of most important aspects to consider when assessing social performance and positive contributions to sustainability

Prioritization of aspects to consider when assessing social performance		Prioritizations of aspects to consider when assessing positive contributions to sustainable development	
Items aggregated in first round	Mean values of experts' ratings from final round on nine-point-scale	Items aggregated in first round	Mean values of experts' ratings from final round on nine-point-scale
Health and safety situation	8.06	Reduction of negative sustainability issues/problems (e. g., reduction of emissions, costs, accidents)	8.08
User health and safety	8.03	Development of sustainable business models	7.44
Transport safety	7.59	Preventive avoidance of negative sustainability issues/problems (e. g., conservation of resources, protection of species)	6.64
Consumer information for sustainable product application	7.44	Fair trading	6.52
Transparency about final destination of waste and unused parts	7.31	Completeness and quality of product information	5.96
Suppliers' health and safety situation	7.15	Contribution towards a circular economy (e. g., cradle-to-cradle product design, recyclability, reusability, reparability, upgradeability)	5.92
Hazardous (toxicity) potential of product specific materials	6.42	Cooperation with suppliers	5.92
Socially responsible waste management infrastructure	6.34	Health and safety (e. g., life expectancy)	5.88
Products' functional utility	6.28	Economic gains for individual stakeholders along the life cycle (e. g., income, wages and salaries)	5.52
User education about sustainable disposal	6.25	Quality of ingredients (e. g., organically sourced)	5.52
Legal compliance of suppliers' operations	6.18		
Life span and long-term support of sold products	5.97		
Fair pricing and affordability	5.84		
Compensation of workers (wages etc.)	5.82		
Effects of transportation on infrastructure	5.72		
Ethical advertising	5.63		
Hazardous (toxicity) potential of product-specific materials	5.59		
Suppliers' conduct towards the least (children, uneducated etc.)	5.53		

Note that the participating experts were asked to rate the importance of each item on a nine-point scale ranging from not at all important (= 1) to extremely important (= 9)

nen and Hahn 2017). By evaluating the opinions of various experts from the field, the iterative Delphi study identifies such relevant characteristic aspects and provides a prioritization of the most important aspects of social and positive sustainability performance. Table 3 presents the relative importance of the characteristic aspects of social and positive sustainability performance, and thus guided the prioritization of relevant indicators for the Handprint approach.

3.3 Description of the handprint approach

Overall, the assessment and evaluation approach of the Handprint adapts the established conceptual framework of conducting ELCA as outlined in ISO 14040 and 14044. Fig. 3 illustrates the four phases of the Handprint approach: Goal and scope, data inventory, evaluation, and interpretation.

First, the *goal and scope* definition phase describes the objective of the assessment as well as the product, defines functional unit, and the system boundaries (i. e., the relevant life cycle stages considered). The Handprint contains a pri-

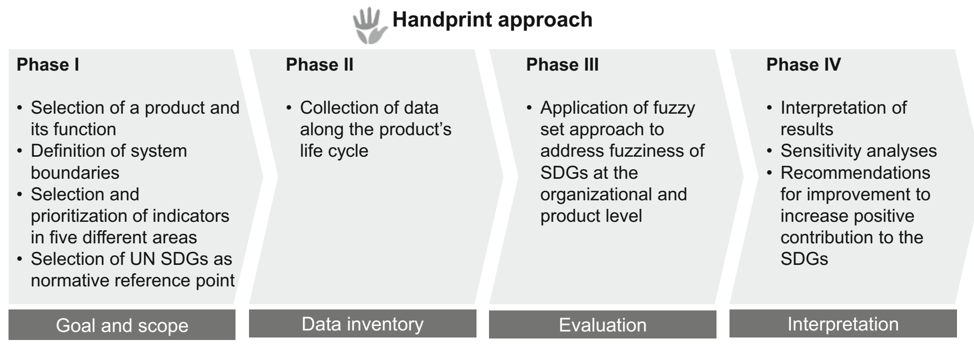


Fig. 3 Illustration of the phases of the Handprint approach

oritized pool of indicators allocated to three areas, (1) social, (2) environmental, and (3) economic, governance, and institutional. Table 4 provides an overview of the identified 37 indicators addressing these three areas and the related SDGs. Because the SDGs and sub-targets mostly provide vague and imprecise criteria and indicators to judge organizational contributions to sustainable development, the indicators provided in Table 4 are not meant to be precise indicators of the SDG sub-targets. Instead, the indicators are meant to show the relationship between organizational actions and their "fuzzy" contributions to the SDGs and sub-targets. The indicators were selected through the iterative process described in the previous sections. To support the practicability and flexibility of the Handprint approach, the prioritization of social and positive sustainability aspects from the Delphi studies can guide the prioritization of the overall pool of indicators for various product cases. For the *data inventory* compilation and analysis, data must be collected and compiled from the companies along the product's life cycle. Furthermore, a classic impact assessment will be conducted for environmental impact indicators, e. g., global warming potential.

In the third phase of the Handprint approach—the *evaluation* phase—the approach proposed in ISO 14040/44 is adapted to evaluate a product's potential positive contribution to sustainable development. A normative value system is required as a reference point to describe the relationship between the selected indicators and potential contributions to sustainable development. Therefore, the UN SDGs were chosen as a reference point to evaluate the potential sustainability contributions of products. The decision for the SDGs was based on an analytical comparison of different sustainability frameworks. The SDGs are particularly suitable because they were adopted by the General Assembly of the United Nations and thus by representatives of almost all countries of the world. Thereby, the SDGs are a democratically legitimated and globally consensual framework. Furthermore, the SDGs address all dimensions of sustainability. However, Verboven and Vanherck (2016) note that the SDGs only partially provide hands-on and actionable criteria to capture businesses' impacts on sustainability. Therefore, after setting the SDGs as target for evaluation, we investigated to which of the 17 SDGs (including 169 sub-goals) companies can make a clear contribution. Only some of the SDGs can be reasonably related to the prioritized selection of product indicators (e. g., through wages paid or emissions caused in the production process). The subsequent discussion section discusses this evaluation step in more detail.

Finally, for the *interpretation* phase, the results of the Handprint approach are to be interpreted and critically evaluated in terms of their robustness and potentials for increasing a product's positive contributions to sustainable development. Suitable measures for robustness and best practices on how to interpret the results are in development and evolve with the continuous application of the Handprint, especially in the case studies. Thus, the Handprint aims at solving environmental and societal challenges, fostering positive changes along product life cycles, and supporting a sustainability transformation of business and society.

4 Discussion

4.1 Evaluation approach for capturing positive contributions to the SDGs

The SDGs represent consensual targets on a global scale and provide a potential normative foundation and evaluative reference point to capture positive contributions to sustainable development (Schaubroeck and Rugani 2017; Verboven and Vanherck 2016). However, the goals mostly provide vague, imprecise, and qualitative criteria to capture and evaluate contributions to sustainable development at organizational or product level (Verboven and Vanherck 2016). To allow for a quantified assessment, the Handprint borrows from the basic rationale to assess a product's potential impact on biodiversity proposed by Lindner (2015) who argues that biodiversity is a "fuzzy, ambiguous term and can hardly be properly defined as a political goal" (p. 6), just as many of the SDGs are. Lindner (2015) incorporates fuzzy set theory thinking (Zadeh 1965) to de-

Table 4 Overview of preliminary Handprint indicators that address SDGs

Area	Indicators (related SDGs) and measurement approaches
Social aspects	Average workers' wages compared to minimum wage and living wage (SDGs 1.1; 8.5); measured by daily average wages paid to workers of the lowest income category above the national minimum wage per day (if it is above the bare minimum of 1.25 US Dollar per day set by the UN) Expenses on social security (SDGs 1.3; 8.5); measurement approach in development Ratio of women's wages to men's wages in different salary categories (SDG 8.5) Integration of disadvantaged people (SDG 8.5); measurement approach in development Number of cases of child labor in the product life cycle (SDG 8.7) Number of cases of forced labor in the product life cycle (SDG 8.7) Number and/or loss of time caused by accidents at work or work-related diseases (SDGs 3.9; 8.8) Number of workers having access to protective equipment (SDGs 3.9; 8.8) Capacity building (SDGs 4.7; 13.3); measurement approach in development Human toxicity potential (SDGs 3.9; 12.4); measured as in established LCA approaches Ozone depletion potential (SDGs 3.9; 12.4); measured as in established LCA approaches Photochemical oxidants potential (SDGs 3.9; 12.4); measured as in established LCA approaches Radiation potential (SDGs 3.9; 12.4); measured as in established LCA approaches Particulate matter potential (SDGs 3.9; 12.4); measured as in established LCA approaches Particulate matter potential (SDGs 3.9; 12.4); measured as in established LCA approaches
Environmental aspects	Terrestrial biodiversity potential (SDGs 2.4; 2.5; 6.6; 12.4; 15.1; 15.4; 15.5); measurement approach in development Volume of wastewater (SDG 6.3); measured by volume of wastewater disposed into the environment reduced Freshwater eutrophication potential (SDG 6.3); measured as in established LCA approaches Freshwater toxicity potential (SDG 6.3); measured as in established LCA approaches Volume of water use (SDG 6.4); measured as in established LCA approaches Water scarcity potential (SDG 6.4); measured as in established LCA approaches Land use (SDG 6.6); measured as in established LCA approaches Sustainable use of resources (SDGs 12.5); measured by the percentage of reused or recycled product material in relation to the total mass of the overall product Amount of waste (SDGs 12.4; 12.5); measurement approach in development Eco-toxicity potential (SDGs 6.3; 12.4); measured as in established LCA approaches Global warming potential (SDG 13); measured as in established LCA approaches Marine eutrophication potential (SDG 14.1); measured as in established LCA approaches Marine toxicity potential (SDG 14.1); measured as in established LCA approaches Marine acidification potential (SDG 14.3); measured as in established LCA approaches Marine biodiversity potential (SDGs 14.4; 14.5); measured as in established LCA approaches Soil quality potential (SDGs 15.3; 15.5); measured as in established LCA approaches
Economic, governance, and institutional aspects	Distribution of (technological) solutions for sustainability (SDGs 17.6; 17.7); measurement approach in development Investments in R&D focusing on sustainability, sustainable entrepreneurship, infrastructure, and trainings (SDGs 9.5; 17.3; 17.7; 17.16); measured by amount of financial investments Sustainability (risk-) management in companies and throughout the value chain (SDGs 12.2; 12.6; 16.3); measurement approach in development Transparency and standards on company and product level (SDGs 12.6; 12.8); measured by a preliminary scoring scheme (i. e., one point can be obtained for each of the following aspects: Adherence to a relevant social or environmental standard; adherence to a social and environmental standard or holistic sustainability standard; independent auditing or at least one standard) Active communication of sustainability issues (SDG 12.8), measured by a preliminary scoring scheme (i. e., one point can be obtained for each of the following aspects: Sustainability reporting without according to a relevant standard, sustainability reporting in partial accordance with a standard, sustainability reporting in accordance with a standard, and sustainability reporting in accordance with a standard including an assurance statement) Violation of law, e. g., in terms of anticompetitive behavior, tax evasion, violation of environmental law, violation of laws for social and labor protection (SDG 16.3); measurement approach in development Engagement in setting sustainability standards and legislation supporting sustainable development (SDG 16.6); measured by a preliminary scoring scheme (i. e., one point can be obtained for each of the following aspects: Developing own publicly available standards that go beyond legal requirements; engaging with stakeholders when developing own publicly available standards beyond legal requirements; active membership in initiatives for developing publicly available industry- or cross-industry standards that go beyond legal requirements)

fine modelling functions that express the relation between a "management parameter" and its contribution to biodiversity. Correspondingly, the Handprint approach builds on fuzzy set theory (Zadeh 1965) to establish an evaluation approach that addresses the verbal fuzziness of the SDGs for business organizations and their products because fuzzy set theory "is particularly well suited as a bridge between natural language and formal models" (Zimmermann 2010, p. 329).

Fuzzy set theory argues that the key element of human thinking are words and not numbers (Pavláková Dočekalová et al. 2017). Verbal expressions about sustainability perfor-

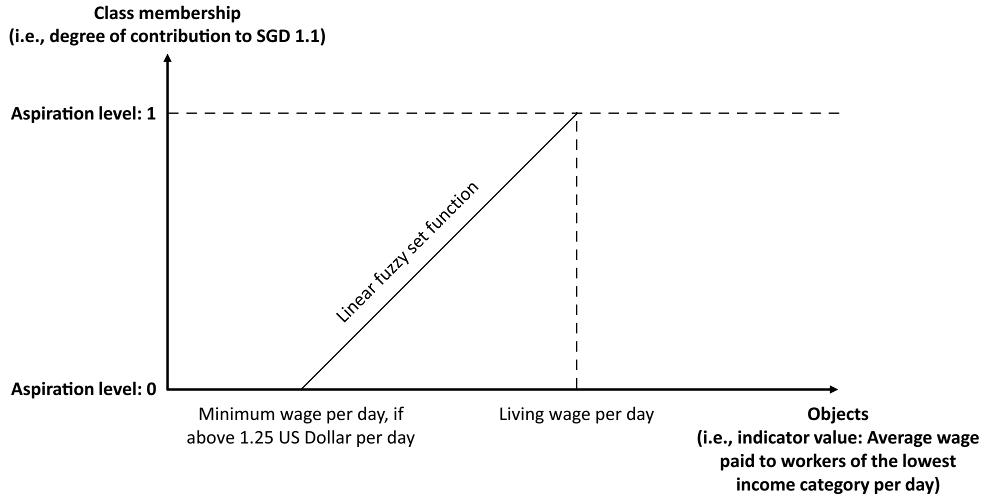


Fig. 4 Illustration of the evaluation phase of the Handprint approach based on an exemplary linear fuzzy function

mance are often subjective, uncertain, and vague (Govindan et al. 2013). Fuzzy set theory addresses the imprecision and vagueness (i.e., fuzziness) contained in human language, judgments, and decisions (e.g., related to contributions to sustainable development) when objects do not have precise criteria of class membership (Zimmermann 2010). Zadeh (1965) defines a fuzzy set as "a class of objects with a continuum of grades of membership" (p. 339). For example, the class of animals includes the objects of cats and dogs, whereas the object of bacteria have an ambiguous status regarding the class of animals (Zadeh 1965). Similarly, the class of 'contributions to sustainable development' includes objects such as 'paying decent and fair wages to workers', whereas the 'actual level of wages paid to workers' can be an ambiguous object regarding sustainable development.

A fuzzy set (i.e., class of objects) is characterized by a "membership function which assigns to each object a grade of membership ranging between zero and one" (Zadeh 1965, p. 338). An object with a membership grade of one is in the set, whereas an object with a membership grade of zero is not in the set (ambiguous objects are assigned with values between zero and one; Govindan et al. 2013). Zimmermann (2010) argues that linear functions are the most basic and practical approximation to model human language (non-linear functions are also possible; e.g., Dhingra et al. 1992). Such fuzzy linear functions can be defined by fixing two points, that is, the lower and upper aspiration levels that humans want to achieve (Zimmermann 2010). Transferring this fuzzy set theory logic to the Handprint, the evaluation approach assigns a grade of membership between zero and one on a function between a lower aspiration level (i.e., no contribution to the SDGs = Zero) and an upper aspiration level (i.e., contributions to the SDGs = One) to each selected indicator.

Fig. 4 illustrates the evaluation approach by defining an exemplary linear fuzzy set function that expresses the relation between the selected indicator of low-income wages and the SDG 1.1 ("By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day"; UN 2015). This illustrative exemplary linear function is based on the judgments of the project team after several iterative rounds of discussion with external stakeholders. We argue that the function is set between the lowest aspiration level (Zero; where the daily average wages paid to workers of the lowest income category just reach the national minimum wage per day, if it is above the bare minimum of 1.25 US Dollar per day set by the UN) and the upper aspiration level (One; where the daily average wage paid to workers of the lowest income category reaches or exceeds the regional living wage). Thus, this fuzzy set function illustrates contributions to SDG 1.1. At the time of writing, further fuzzy set functions were under development and being tested in the case studies.

4.2 Pilot case study to test the feasibility of the Handprint approach in practice

The preliminary Handprint approach was subject to intensive testing in several case studies of selected products in cooperation with industry partners. For this purpose, case study partners from three different sectors (home furnishing, electronics, and food) with end-consumer (rather than business-to-business) products were selected. The objective of the case studies was to test the feasibility of the Handprint approach (in particular of the selected indicators), evaluate limitations and challenges, and reveal opportunities for further refinement. Each case study sets a focus to specific challenges of the Handprint approach. To demonstrate the feasibility of the Handprint approach in practice, this section presents a summary of preliminary results from a selected pilot case study (see Table 5) that focused on a sustainably manufactured computer mouse, which was compared to a conventional computer mouse.

Table 5 Pilot case study "computer mouse" of the Handprint approach

Handprint phases	Description of the Handprint phases in the case study	Evaluation of feasibility of the Handprint phases and differences with the classic ISO 14040/44 framework
Goal and scope definition	The goal of the case study is to test the applicability of the Handprint approach by comparing and evaluating two alternative computer mice in terms of their contributions to sustainable development. The first (to be tested) *sustainably manufactured computer mouse* is (partially) made of recycled secondary materials such as solder alloys for the circuit board and renewable resources such as bio-plastics for the casing and wood for the scroll wheel. Furthermore, the manufacturer of the mouse claims to promote transparent and sustainable production practices along the life cycle (e. g., by cooperating with suppliers that compensate fairly or by enabling individuals with disabilities to work in constructing the final product). The alternative *conventional computer mouse* is made of crude-oil-based components and is manufactured under typical working conditions in the electronics industry. The manufacturer (and most of its first-tier suppliers) of the sustainably manufactured mouse are located in Germany, whereas manufacturing of the conventional mouse is located in Asia. The system boundaries of both product alternatives include the sourcing from first-tier supplier and the manufacturing. Transport and distribution of the components are cut-off. The case study focuses on several indicators selected from the environmental, social and economic areas of the Handprint indicator pool (for an overview of Handprint indicators, see Table 4). For environmental indicators, this case study exemplarily discusses the indicator "use of resources" to investigate differences in environmental performance by comparing the use of recycled solder alloys against conventional solder alloys between the product alternatives	Overall, defining the goal and scope of the Handprint pilot case study is feasible. Analogous to the ISO 14040/44 framework, the Handprint approach builds on a clear definition of the primary goal and scope of the study, for example aiming at an analysis and comparison of alternative production systems with the same system boundaries that fulfill the same functional benefit for the product user
Data inventory	For the data inventory compilation and analysis in this pilot case study, specific primary data for the sustainably manufactured mouse is collected and compiled from the companies within the defined product system boundaries. For the conventional computer mouse, available generic secondary data was collected and used for analysis	The Handprint aims at integrating data from all sustainability dimensions. Although compiling the Handprint data inventory is generally feasible, it is a more laborious and complex task compared to compiling inventory data on energy and material flows for conducting a classic ELCA according to ISO 14040/44
Evaluation	The preliminary results indicate that efforts regarding the use of recycled materials and use of bio-plastics to manufacture the sustainable computer mouse offer the potential of significant reductions of greenhouse-gas emissions. However, potential negative impacts of the sustainably manufactured mouse in terms of classic environmental impacts (e. g., intensive land-use due to sugar cane production in Thailand) were also identified	In the third phase of the Handprint approach, an evaluation step based on fuzzy set theory was introduced, which is a substantial deviation from the classic ISO 14040/44 framework. The preliminary results of the case study show that the evaluation approach of the Handprint is generally applicable. However, the preliminary fuzzy set functions developed thus far clearly need to be refined and validated in the future to achieve a higher level of validity and reliability
Interpretation	The intended goal of the case study was to test the feasibility of the Handprint approach by comparing and evaluating two alternative computer mice in terms of their potential positive contributions to sustainable development. Overall, the preliminary results point to the general feasibility of the approach. It should be noted that the production systems, indicators, and fuzzy set functions in this pilot case study were selected for a general test of feasibility, and not for a complete and exhaustive evaluation and assessment of the product alternatives	Equivalent to the ISO 14040/44 framework, the interpretation phase of the Handprint approach aims at a critical summary and analysis of the results of the inventory and evaluation phases to provide a set of conclusions and recommendations. The interpretation includes the identification of the most critical issues of the Handprint assessment results as well as an evaluation of the Handprint study's completeness and accuracy. Overall, we conclude that the Handprint interpretation is generally feasible without significant differences compared to the interpretation phase in the ISO 14040/44 framework

The Handprint approach builds on and adapts the established ISO 14040/44 framework. Therefore, we compare the differences between the Handprint phases and the established ISO 14040/44 framework

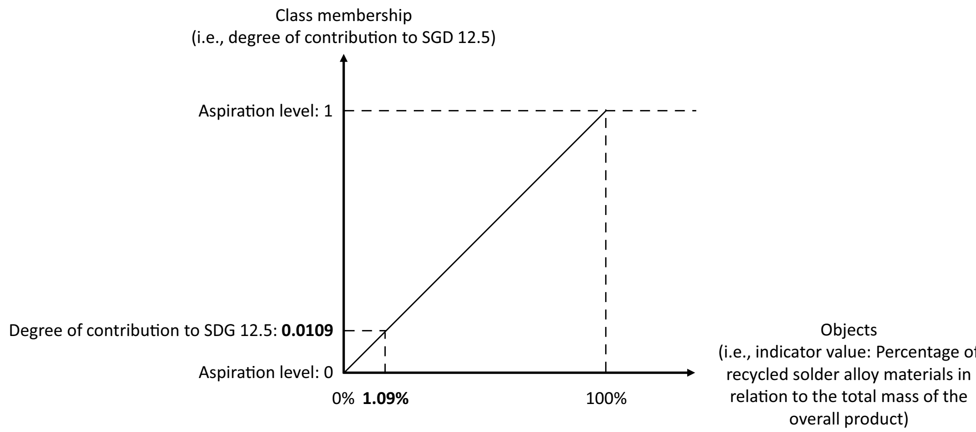


Fig. 5 Illustration of the fuzzy relationship between the indicator "sustainable use of resources" and the related SDG 12.5

This pilot case study is structured along the previously introduced four phases of the Handprint approach (see Fig. 3) to prove the preliminary feasibility of the approach. Each phase is first presented with a description of the case study in terms of the general activities and results. Furthermore, the feasibility of the handprint approach is critically evaluated, including a short comparison with regard to the classic ISO 14040/44 ELCA framework (i.e. goal and scope definition, inventory analysis, impact assessment, and interpretation). In particular, the pilot case study specifically investigated the applicability of a linear fuzzy set function that expresses the relation between the selected indicator "sustainable use of resources" and the SDG 12.5 that vaguely demands "By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse" to ensure sustainable consumption and production patterns.

The indicator "sustainable use of resources" is designed to measure the percentage of specific recycled materials in relation to the total mass of the product. The material investigated in this case study is a recycled solder alloy for the circuit board of the sustainably manufactured computer mouse. Fig. 5 illustrates the fuzzy relationship between the indicator "sustainable use of resources" and the related SDG 12.5. The linear fuzzy function has a 45 degree angle because we argue that achieving a 100% recycling quota until 2030 would imply that SDG 12.5 is fully achieved (i.e. a fuzzy aspiration level of one). The mass of the overall sustainably manufactured mouse is 87 g, while the mass of the recycled solder alloy is 0.95 g. Therefore, the percentage of recycled solder alloy in relation to the total mass of the mouse is 1.09%. In turn, transferring this value from one axis to the other shows that from the percentage of recycled solder alloy (in relation to the total mass of the overall computer mouse) of 1.09% corresponds to a degree of 0.0109 points of contributing to the SDG 12.5.

A critical issue in the pilot case study was that the solder alloy was one of the few product materials for which data along the complete life cycle has been available. This represents a critical issue for a number of components and requires further analysis and the development of databases. The presented pilot case study confirms that the approach is applicable to companies in different sectors and with global operations. However, it remains a laborious task requiring significant investments of time and resources to complete and substantiate the approach.

4.3 Critical evaluation of the Handprint approach

While striving to address the identified shortcomings of existing sustainability assessment approaches, the Handprint also has certain limitations, which should be addressed in future research. A limitation is that the approach is complex in terms of data collection and evaluation. The different types of data require expertise of the assessor to gather quantitative and qualitative data from different areas, such as environmental, social, and economic aspects. Data collection is especially challenging and time intensive, as current databases often include a wide range of environmental data but lack social data. Furthermore, as in ELCA, data need to be compiled from sources across the whole supply chain because the Handprint approach builds on life cycle thinking. Moreover, the results of a Handprint assessment should never be communicated without adding the results of a Footprint assessment for the same product or service in order to avoid greenwashing.

Overall, the aim of positive contributions to sustainable development along product life cycles and corporate supply chains has so far received little attention. The Handprint incorporates the SDGs as an orientation for sustainability assessment. While this orientation can be helpful, some aspects, such as animal welfare, are not (yet) covered (Eberle and Schmid 2016). The application in practice will contribute to a detailed and refined set of indicators. The aim of achieving practicability represents a certain trade-off to the scientific preciseness of the results, which is a typical issue in life cycle assessment approaches (Freidberg 2018). Therefore, the Handprint requires more testing and application in practice. The next phase of the project aims at finishing further case studies to improve and fine-tune the approach. Throughout the case studies, the indicators will be tested and potentially erased or complemented. Testing and further research on the different phases of the Handprint approach represent important avenues for future research.

5 Conclusion

The objective of the Handprint is to provide an approach to assess positive contributions to sustainable development. The approach provides a number of opportunities. Primarily, we argue that extending the corporate sustainability narrative from focusing on reducing negative impacts to positive sustainability contributions encourages businesses to engage in creating contributions to a sustainable development of society. Currently, academics and decision-makers in business practice and government have the habit of assuming that the key question when facing trade-offs (e. g., weighing jobs in the fossil energy sector against the environmental benefits of renewable energy, or benefits of the present generation against opportunities of future generations) is: Which side to favor to mitigate adverse effects to a point of acceptability (Gibson 2013)? However, decision-makers rarely evaluate trade-offs with adequate care about the interdependencies of sustainability because mitigating adverse effects is important but insufficient by itself to deliver the needed transition to a more sustainable future. The new narrative of the Handprint is therefore attractive for business leaders, political leaders, and governance actors in another, more positive way.

The development of the Handprint underwent an exhaustive and iterative mixed-method approach. A broad range of experts from academia, business practice, and stakeholders from civil society were involved in iterative rounds of discussion and refinement. Thus, the Handprint project team designed an empirically based assessment approach that strives for a balance between comprehensiveness (by addressing sustainability holistically covering social, environmental, and economic, including governance and institutional, aspects), as well as practicability (by iteratively narrowing the number of indicators selected). Furthermore, we particularly elaborate how businesses and products contribute to achieving the SDGs by incorporating fuzzy set theory into the evaluation step of the Handprint approach. Thus, the Handprint aims at shifting the focus from reducing unsustainable, negative business practices toward positive contributions to sustainable development in sustainability assessment and management.

Moreover, the orientation toward positive sustainability contributions offers a vision toward a sustainability transformation of business and society. Consequently, sustainability performance measurement can also support sustainable entrepreneurship as a constructive, positive approach to creating sustainability transformations. Sustainable performance measurement is challenged to evaluate how human and industrial systems provide benefits to nature and human well-being, and thus, support decision-makers in recognizing and realizing win-win opportunities for business and society (Beske-Janssen et al. 2015). Consequently, the Handprint provides a critical contribution to overcoming the typical negative paradigm that humankind damages the environment.

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Conflict of interest M. Kühnen, S. Silva, J. Beckmann, U. Eberle, R. Hahn, C. Hermann, S. Schaltegger and M. Schmid declare that there is no conflict of interest.

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