Impact of sustainable product development tools through intermediaries: A multi-actor study of pathways and conditions

Journal of Cleaner Production 572 (2026) 148906

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Impact of sustainable product development tools through intermediaries: A multi-actor study of pathways and conditions

Jesko Schulte [a,*], Sophie I. Hallstedt [a,b], Matilda S. Watz [a], Irene Lo Vecchio [c], Matteo Caprioli [c], Silvia Zanazzi [c]

[a] Department of Strategic Sustainable Development, Blekinge Institute of Technology, Valhallavägen 1, Karlskrona, SE-371 79, Sweden
[b] Department of Industrial and Materials Science, Chalmers University of Technology, Chalmersplatsen 4, Gothenburg, SE-412 96, Sweden
[c] NATIVA S.r.l. SB, Piazzale Clodio 22, Rome, Italy

HIGHLIGHTS

- Academia-consultants-clients interplay in sustainable product development.
- Factors that make academic tools attractive for consultants and clients.
- Sustainable Product Development impact: type, magnitude, and permanence.
- Layered and time-phased impact pathway model.
- Multi-actor recommendations for increased use and impact.

ARTICLE INFO

Keywords:
Academia-industry interface
Knowledge transfer
Multiple case study
Strategic life cycle assessment
Sustainable design
System innovation

ABSTRACT

This study provides an empirically grounded, multi-actor investigation of how industrial impact of sustainable product development (SPD) tools forms along the pathway from academic tool development, through intermediary adoption and adaptation, to client application, and under what conditions impact unfolds over time. A multi-actor, multiple-case design, combining an embedded consultancy case with cross-sector client cases was employed, using interviews and follow-up questionnaires to explore how consultants adopt and adapt academically developed SPD tools and how clients experience and assess their application and impact. The analysis shows that adoption by consultants is enabled when tools are proven useable and time-effective in early phases, provide clear visualizations and credible traceability, and can be customized to sector language and practices. Across client cases, the application of SPD tools was perceived primarily as an enabler for innovation and competitiveness, together with increased ability to meet customer needs and improved reputation. The findings indicate a multi-layered and time-phased pattern of impact where impacts were reported most consistently at organizational level, including mindset change, cross-functional dialogue, and prioritization routines, whereas more technical and measurable outcomes emerged more selectively, with time delay, and depended on enabling conditions beyond tool use, e.g., governance and leadership, supplier capability and openness, policy and market signals. System-level change is discussed as a potential downstream pathway when SPD tool use is paired with deliberate work on enabling conditions. The study synthesizes these insights into seven multi-actor recommendations for researchers, consultants, and firms on designing, translating, and embedding SPD tools to maximize impact.

1. Introduction

Product development and manufacturing companies shape not only the environmental and social footprint of products but also the trajectory and pace of systemic change in production and consumption systems (Benn et al., 2018). Their decisions, thus, play a critical role for enabling society's transition toward sustainability, and early phases of product development are particularly decisive as this is where the

* Corresponding author.
E-mail address: jesko.schulte@bth.se (J. Schulte).

https://doi.org/10.1016/j.jclepro.2026.148906
Received 16 March 2026; Received in revised form 22 May 2026; Accepted 3 July 2026
Available online 6 July 2026

majority of a product's life-cycle impacts as design constraints are defined (Brezet and van Hemel, 1997; Hauschild et al., 2018). To support industry's transformation, academia has developed a wide range of methods and tools for e.g., sustainable product development (SPD) and eco-design, aiming to embed sustainability considerations into design and innovation processes (Faludi et al., 2020). Despite decades of research and the existence of more than 600 unique methods and tools for SPD and related domains (Schäfer and Löwer, 2021), practical implementation in industry remains limited and impact unclear (Peace et al., 2018; Vilochani et al., 2024). Barriers include perceived complexity, lack of integration with existing processes, and insufficient alignment with organizational priorities (Dekoninck et al., 2016; Zumach et al., 2025).

While previous studies have explored adoption barriers and enablers (e.g., Mallalieu et al., 2024), significant gaps remain. First, there is limited empirical evidence on the real-world impacts of SPD tools once applied in industrial contexts, such as the nature of these impacts, their magnitude, permanence, and whether they align with intentions and expectations. Second, while consultants are increasingly recognized as key intermediaries who translate academic knowledge into practice (Chatty et al., 2022; Küçüksayraç et al., 2015), it remains uncertain how the interplay between academia and consultancy unfolds in practice and what factors make academically developed SPD tools attractive for consultants to adopt and adapt. Concepts such as the "method ecosystem" (Gericke et al., 2020), "ecodesign change management" (Brones et al., 2017), and "soft side" of sustainable design (Boks, 2006) underscore that successful implementation depends not only on methodological soundness but also on contextual adaptation, usability, as well as people and process management. In this context, consultants often function as "knowledge couriers" who disseminate ideas, e.g., by customizing tools for specific sectors and facilitating their integration into client workflows, thereby serving as "translators" between academic researchers and industry practitioners (Koria et al., 2022).

This study investigates how industrial impact forms along the pathway from academically developed SPD tools, through intermediary adoption and adaptation, to application and outcomes in client organizations. A multi-actor design is used to capture this pathway empirically by combining an embedded consultancy case (intermediary perspective) with cross-sector client cases (application and outcome perspective). The following research questions are addressed:

- RQ1: What are success factors for adoption of SPD tools among intermediaries such as business and design consultants?
- RQ2: What industrial impacts can be linked to the application of SPD tools?

By addressing these questions, the study's primary contribution is an empirically grounded, multi-actor explanation of impact formation: what kinds of impacts materialize, their magnitude, how they evolve over time, and under what conditions they translate into more material outcomes. The intermediary case provides evidence on the adoption and adaptation mechanisms that enable tool translation into practice, while the client cases show where impacts emerge first and why downstream outcomes vary. In combination, these findings clarify the conditions under which SPD tools move beyond conceptual robustness to become embedded decision support that shapes industrial practice. Synthesized into seven recommendations, these findings offer guidance for (i) researchers on designing tools that are scientifically robust yet adaptable, useable, and capable of creating benefits in industrial contexts; (ii) consultants acting at the intersection between academia and industry to support an accelerated industry transformation to SPD; and (iii) industry on leveraging SPD support to achieve lasting impact.

2. Literature review

To frame the study, this section first synthesizes the intentions and observed impacts of SPD tools and then addresses the knowledge-transfer perspective with a focus on intermediaries.

2.1. Sustainable product development: intentions and impacts

Decades of research have produced a broad repertoire of methods and tools, from guidelines and checklists to assessment approaches and portfolio-level tools, intended to embed sustainability in design and innovation (Faludi et al., 2020; Schäfer and Löwer, 2021; Pigosso et al., 2015). Foundational work emphasized early design choices and life-cycle strategies (Brezet and van Hemel, 1997; Luttropp and Lagerstedt, 2006; Lewis et al., 2001). Within this landscape, SPD seeks to integrate a strategic sustainability perspective and life-cycle thinking in early innovation phases where design constraints are set (Hallstedt and Isaksson, 2017). Several conceptual and methodological traditions have shaped SPD. Among these are the Framework for Strategic Sustainable Development (FSSD), emphasizing backcasting from sustainability principles and the need for systems thinking (Broman and Robèrt, 2017). Tools that operationalize these ideas include Strategic Life Cycle Assessment (SLCA), which supports qualitative, principle-guided assessments across a product's life cycle to identify hotspots and guide prioritization (Ny et al., 2006), and an overarching Method for Sustainable Product Development (Byggeth et al., 2007). More recently, the Sustainability Fingerprint method provided portfolio-oriented, visualization-rich assessments intended to support early-phase decision-making, prioritization, and communication (Hallstedt et al., 2023a).

Despite this rich method landscape, implementation and verified impact in practice remain limited. Research has for a long time highlighted the need of integration with engineering processes and realities of industrial practice, stressing usability, organizational fit, and decision support under time and information constraints (Baumann et al., 2002; Bhamra and Hernandez, 2021; Lofthouse, 2006). Uptake is further hindered by perceived complexity, low compatibility with existing workflows, and weak alignment with business priorities (Dekoninck et al., 2016; Peace et al., 2018; Mallalieu et al., 2024). Furthermore, reviews repeatedly conclude that claimed benefits from tool applications in industry seldomly are verified with empirical data on realized outcomes; a general challenge in design research where available evidence tends to be limited to adoption or process outputs rather than performance or durable change (Baumann et al., 2002; Gericke et al., 2022; Pigosso et al., 2015; Schäfer and Löwer, 2021). Despite some emerging research on how SPD practices may relate to product sustainability performance (Vilochani et al., 2025), there is limited comparative insight into what types of impacts SPD tools yield (e.g., environmental, social, organizational), their magnitude, and their permanence or diffusion over time, as well as the conditions under which impacts are more likely to materialize. Translating method benefits into robust, quantitative business metrics often requires longitudinal validation beyond typical project horizons (Hallstedt et al., 2023b).

Recent empirical work suggests that the main obstacles to translating sustainable design ambitions into sustained practice are strategic and organizational rather than tool-technical, including unclear links to profitability, limited top-management support, and difficulties handling trade-offs (Schöggl et al., 2024). Complementary evidence indicates that firms increasingly build internal sustainability structures (e.g., training, guidelines, KPIs), yet systematic process integration remains uneven (Höpfl et al., 2026). In parallel, intermediary research highlights that legitimacy building and ecosystem coordination are recurrent challenges when scaling sustainability-oriented solutions across multiple stakeholders (Spigarelli et al., 2025). The literature therefore points towards two complementary needs. Tools must be both conceptually coherent and practically useable under industrial constraints, and research should move beyond feasibility/adoption to clearer empirical accounts of realized impacts, including how early-phase framing shapes design choices, investments, and organizational practice (Faludi et al.,

2020; Peace et al., 2018; Vilochani et al., 2024).

2.2. Knowledge transfer and the role of intermediaries

Transferring knowledge from academia to industry has long been recognized as a critical yet challenging aspect of innovation and organizational learning, particularly in the context of sustainability (Rossoni et al., 2024; Orecchini et al., 2012). Academic research often produces theoretically robust and methodologically sophisticated tools, but their uptake in industrial practice remains limited (Guertler, 2018). This gap is especially evident in SPD, where the complexity of real-world decision-making collides with the structured nature of academic outputs. Knowledge transfer is therefore not a matter of simple dissemination; it requires translation, adaptation, and contextualization to fit organizational realities (Wallace, 2011). The concept of the "method ecosystem" (Gericke et al., 2020) captures this tension, emphasizing that each organization operates within a unique constellation of processes, constraints, and routines. Academic methods must therefore be adapted to these ecosystems to become useable and valuable. However, previous studies have identified success factors and barriers for method application in industry, including organizational routines, cognitive biases, and resource constraints (Guertler, 2018; Mallalieu et al., 2024). These findings underscore that adoption is shaped as much by social and organizational dynamics, e.g. terminology, business case articulation, and change resistance, as by technical features (Baldassarre et al., 2020; Burnes, 2015).

Intermediaries such as consultants play a key role as translators and brokers at the academia–industry interface, bridging epistemic gaps and mediating between different organizational cultures, priorities, and languages (Küçüksayraç et al., 2015; Soares, 2024). They combine academic literacy with practical experience to interpret and reframe complex sustainability concepts in terms that resonate with client priorities. By customizing tools for sector-specific contexts, simplifying language, and integrating methods into existing processes, they reduce resistance and increase the relevance of the academic support (Chatty et al., 2022; Koria et al., 2022). Rather than relying on static guidelines or one-off training, pragmatic, transparent tools and participatory adaptation have been shown to enhance alignment, ownership, and long-term integration (Peace et al., 2018; Chatty et al., 2022).

Despite these opportunities, significant challenges remain. Speed mismatches between academia and consultancy, trade-offs between comprehensiveness and practicality, and limited formal recognition of adapted tools can hinder effective interplay (Küçüksayraç et al., 2015; Koria et al., 2022). Moreover, while intermediaries facilitate adoption, impact also depends on client-side governance and resources, underscoring the need to understand how intermediaries influence not only uptake but also outcomes achieved in practice (Gericke et al., 2022; Mallalieu et al., 2024).

3. Methods

This study adopts a multi-actor, multiple-case design to investigate the impact pathways and conditions from SPD tool development in academia, through uptake by intermediaries, to industrial impact. The design therefore combines two parts: firstly, an embedded case of the Italian consultancy company NATIVA S.r.l. SB (NATIVA) - a certified Benefit Corporation founded in 2010 with ca. 70 employees focusing on supporting businesses transform towards regenerative practices, creating positive social and environmental impact while improving business potential. Secondly, a multiple case investigation of NATIVA client organizations across sectors. This design enabled depth (process understanding and perceptions among consultants) and breadth (variation in application contexts and outcomes across clients) (Eisenhardt, 1989; Maxwell, 2013; Yin, 2018). NATIVA was selected because it is an intermediary organization that has operationalized academically grounded SPD tools in client work for more than 10 years, creating a concrete empirical setting in which tool uptake, adaptation, and application can be studied. In addition, NATIVA's practice is grounded in a strategic sustainability framing and includes repeated application and tailoring of SPD tools across client contexts, which enables examination of both intermediary-side adoption logics and client-side outcomes across sectors over an extended period of time.

In phase 1 (intermediary perspective), 1-h, semi-structured interviews with six NATIVA SPD experts were conducted in the spring of 2025 to understand adoption, adaptation, and application of academically developed SPD tools, and the consultants' perceived industrial impact. NATIVA's use of these SPD tools with clients was undertaken without any contact or influence from the research team. All interviewees had an academic background on Master's or PhD level and substantial experience across industries (three with $\approx$3 years and three with $\geq$10 years of client-facing SPD work). Questions addressed the capability needs for adopting academic tools, success factors for adoption/adaptation, usefulness/usability/applicability, perceived value and impact, and perceived challenges and outlook. Interviews were held in English, recorded, and transcribed. Two researchers were present in all cases. Interviews were followed up by a questionnaire (response rate 100%) using a 1–4 Likert scale to triangulate and gather anonymous quantitative information on which factors, see Table 1, the respondents perceive as (un)important for adoption, adaptation, and application of SPD methods and tools.

In phase 2 (client perspective), client organizations were sampled from NATIVA's client portfolio among those that had applied the studied

Table 1
Factors included in the survey; based on Mallalieu et al. (2024) and Peace et al. (2018).

Intuitive Design	Simple and intuitive user interface.
Clear Documentation	Comprehensive and well-organized documentation that provides guidance on how to understand and implement the tool.
Interoperability	Can easily integrate with existing systems and software used in the industry.
Transparency	It is easy to track what assumptions that were used and how results were created.
Comprehensiveness	Covering ecological and social aspects, life-cycle perspective, etc.
Standards	Adherence to industry standards and protocols.
Active Community	A strong user community can provide support, share experiences, etc.
Technical Support	Availability of support services.
Relationship	Possibilities to get in contact with the academics who developed the method/tool.
Popular Science Material	There is popular science material that describes and explains the method/tool beyond mere scientific articles.
Training Programs	Availability of training sessions, workshops, and tutorials.
Educational Resources	Access to case studies, examples, and best practices.
Affordability	Tools are cost-effective or free.
Time-effectiveness	Tools are time-effective and not too time consuming to use.
Open Source	Flexibility and the ability to customize them to specific needs.
Availability	Access to an actual version of the tool, e.g. templates, excel files, etc.
Track Record	Proven track record of success in similar industries or applications.
Endorsements	Positive reviews and endorsements from reputable industry leaders.
Uncertainty and data	Possible to use both qualitative and quantitative data and to account for uncertainty in data (e.g., when there is lack of accurate/validated data) and/or results.
Result visualization	Visualizations ease result communication.
Benefits and Competitive Advantage	Provide a clear competitive advantage, improve efficiency or provide other clear benefits (e.g., compliance with certification, specific customer demand).

SPD tools and were purposefully selected to achieve variation across sectors. Twenty client organizations were invited to participate; twelve interviews were conducted during the summer and fall of 2025, see Table 2. The interviewees represented organizational functions involved in product development and sustainability work, including roles like sustainability/ESG managers, senior product officers, R&D and product portfolio directors, quality officers, marketing officers, sourcing managers, and quality managers. Interviewees were selected based on their level of involvement and insight into the interaction with the consultancy and company-internal SPD work. Interviews were conducted by NATIVA staff using an interview guide developed by the academic researchers, covering motivations and expectations, application contexts and continued use, perceived impacts and success factors, challenges and limitations, and future outlook. The client interviews were carried out in Italian, recorded, transcribed and translated prior to analysis. The client interviewees were sent a questionnaire (response rate 50%) that mirrored the one from phase 1. Interview guides and questionnaires are available as supplementary material.

Interview data were analyzed using inductive coding and thematic analysis (Flick, 2014), supported by qualitative analysis software NVivo and ATLAS.ti. Consistent with the design, a within-case analysis (coding per transcript, followed by thematic analysis) was conducted for the consultancy to preserve contextual detail on intermediary practices, while a cross-case analysis (coding per interview question in each transcript, followed by thematic analysis) was used for clients to identify patterns across contexts (Creswell and Poth, 2017; Flick, 2007). Coding proceeded iteratively from initial open coding to the consolidation of categories and themes, with memoing and successive synthesis to align emergent themes with the research questions. To enhance transparency and dependability, parallel coding was conducted and thematic syntheses and analytic memos were reviewed and discussed among the academic authors, and triangulation was built into the design through multiple actors and multiple instruments. Data saturation was monitored during analysis by tracking the emergence of new codes and themes across interviews within each actor group (consultants and clients), until the likelihood of additional interviews yielding new themes relevant to the research questions was evaluated as low, and when the thematic structure stabilized during successive coding iterations (Guest et al., 2006). This assessment was applied separately for the intermediary and client datasets, reflecting their different analytic purposes (within-case depth vs. cross-case pattern identification). The questionnaires were used to corroborate and nuance qualitative insights. The analysis flow is summarized in Fig. 1.

Several steps were taken to enhance trustworthiness and address potential sources of bias. First, triangulation was built into the design through multiple actors (consultants and clients), multiple instruments (interviews and questionnaires), and complementary analytic lenses (within-vs. cross-case). Second, peer review of thematic syntheses and memos supported transparency and dependability. Third, the interviewer–interviewee relationship in Phase 2 was handled explicitly: while NATIVA staff interviewed their clients, safeguards included the standardized, researcher-developed interview guide, researcher-only analysis of the transcripts, and triangulation with anonymous questionnaires to reduce social-desirability and relationship biases. Fourth, the sample of clients may involve self-selection bias, resulting in an overrepresentation of engaged and positive clients. The client interviewees were also selected based on their involvement in SPD work, which may affect their perceptions of impact and success. While mitigated through the active inclusion of divergent cases in the sampling process and explicit interview questions around challenges and reasons for lack of impact, this limitation is acknowledged when interpreting client-reported outcomes.

Table 2
Overview of clients.

Company	Sector (SASB)	Size[a]	SPD application with NATIVA	
1	Construction Materials	Large	2 years	2023-2024
2	Construction Materials	Large	4 years	2021-2024
3	Engineering & Construction Services	Large	1 year	2022
4	Biotechnology & Pharmaceuticals	Large	6 years	2021-ongoing
5	Household & Personal Products	Large	3 years	2024-ongoing
6	Apparel, Accessories & Footwear	Large	12 years	2015-ongoing
7	Apparel, Accessories & Footwear	Medium	4 years	2022-2025
8	Apparel, Accessories & Footwear	Medium	3 years	2023-2025
9	Agricultural Products	Medium	3 years	2024-ongoing
10	Processed Foods	Medium	1 year	2023
11	Industrial Machinery & Goods	Medium	3 years	2024-ongoing
12	Toys & Sporting Goods	Small	1 year	2025

[a] Based on Directive 2013/34/EU, as amended by Commission Delegated Directive (EU) 2023/2775.

4. Findings

The results are structured to reflect both sides of the knowledge transfer process: first, consultants' experiences with adopting and adapting SPD tools originally developed in academia are described. Second, clients' experiences with their application and outcomes are presented.

4.1. Academia-consultancy interplay for sustainable product development

NATIVA's engagement with SPD tools began with early exposure to the FSSD, which was described by one consultant as *"[…] the most advanced and complete tool that gets a comprehensive description and the definition of what sustainability means and what it means concretely for companies."* This conceptual foundation influenced the selection of tools, with SLCA (Ny et al., 2006) emerging as a cornerstone. SLCA, originally developed as a "Sustainability Product Analysis matrix" in the early 2000s ((Byggeth and Broman, 2001), became central to NATIVA's approach because of its holistic perspective and adaptability. As one participant explained: *"It was very natural for us to choose the SLCA as the main tool to have the baseline of the product and also to have a road map."* Consultants reported that clients often struggle with limited sustainability knowledge, difficulties interpreting results from established tools such as Life Cycle Assessment (LCA), and uncertainty about ways to move beyond compliance. Many clients seek guidance on how sustainability can create business value and innovation opportunities, while others request support for action planning or comparative product assessments.

The consultants typically approach SPD through a structured process beginning with an in-person workshop to establish a shared conceptual foundation. One consultant emphasized the importance of this step: *"So what are the sustainability principles? What is backcasting? Why are we doing this? How is this different from other approaches which are reductionist that they [the clients] may have encountered or used before and why is it important that all the actors involved are on the same page about the language, about the meaning, about the process, and so on."* Following the workshop, data collection is carried out using a customized online SLCA platform that enables multiple users to work in parallel, generates visual matrices, and supports further data collection, e.g., through structured interviews with internal and external stakeholders across the product life cycle. Consultants highlighted that this process is both educational and practical, helping companies identify hotspots and prioritize actions. Simplified visual outputs—such as color-coded matrices or symbolic scoring are provided to facilitate communication across roles. This

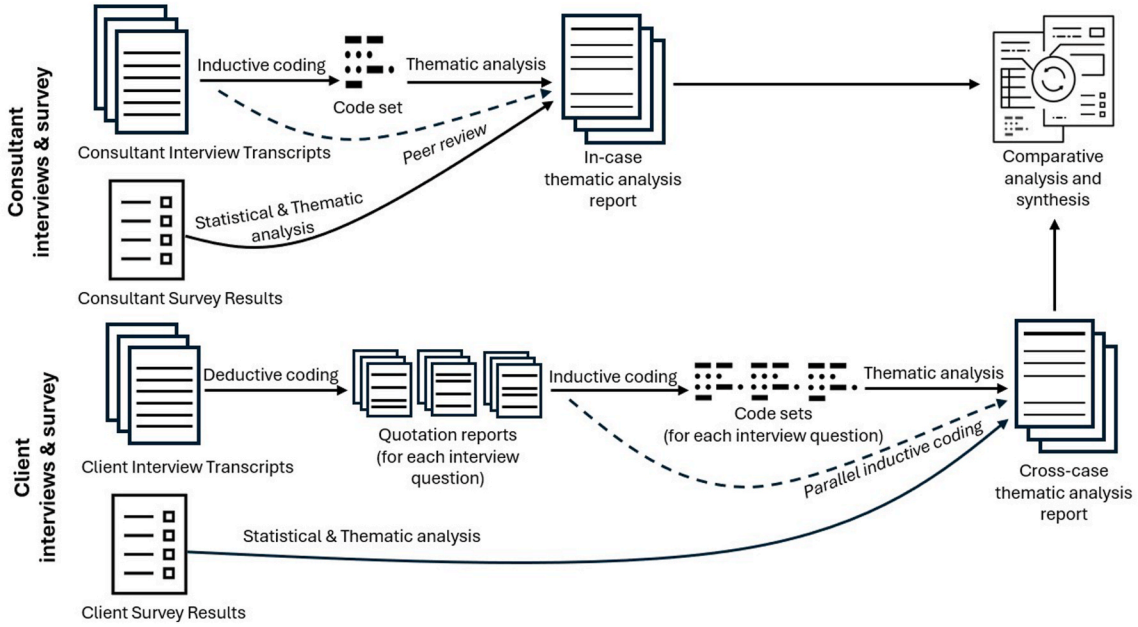

Fig. 1. Data analysis procedure for the empirical data from interviews and surveys.

approach has been applied *"for many years with dozens and dozens of different companies and products."* SLCA's standardized structure is frequently customized for specific sectors such as fashion, chemicals, and electronics, involving reframing questions, simplifying language, and adding examples to improve accessibility. While SLCA is primarily qualitative, consultants often complement it with quantitative indicators to meet regulatory requirements or client expectations. At the same time, the consultants highlighted the importance of avoiding unnecessary complexity: *"We want to give some more quantitative perspective, but this is a different additional aspect that we try to integrate as much as possible, but not to make it too complex for the people that need to use it."*

4.1.1. Preconditions and success factors for tool adoption and adaptation

Dual competence was seen as an essential factor for successful adoption and adaptation of academic SPD tools, as it allows for client-tailoring without compromising conceptual integrity. Consultants expressed the importance of *"a group with a lot of people that have a strong academic background, so there is a mindset for research,"* while *"[…] the prerequisite is that you fully understand the processes at the company level."*

NATIVA's decision to adopt SLCA was based on its established track record, perceived credibility, and comprehensive scope, covering environmental, social, and economic dimensions: *"We always find companies that are highly focused on the environmental aspects, but sometimes they miss or forget about the social aspects or the economic growth."* Beyond conceptual robustness, practical attributes were seen as decisive for adoption, especially (i) flexibility and ease of use, as academic methods often require simplification and translation into language that resonates with practitioners; (ii) time efficiency to fit into fast-paced industrial workflows; (iii) customizability to adapt to sector-specific contexts. If these factors are present, quick wins and visible results are possible to build momentum: *"You need to strive for successes that are concrete and complete and possible to communicate as soon as possible."* Consultants repeatedly stressed the importance of competence-building and client ownership: *"Once they have understood the principles and the criteria, then they have been able to apply also by themselves, which ultimately is our goal. We actually want to train the people, give them the tools then to apply to the rest of their portfolio or have the flexibility of applying it everywhere."*

The questionnaire results, Fig. 2, on perceived importance of adoption factors (Table 1) corroborated these themes, with result visualization, time-effectiveness, intuitive design, and clear benefits ranked highest among consultants. Free-text responses emphasized economic value links, third-party verification, alignment with market drivers and organizational purpose, and ease of internal communication and marketing.

4.1.2. Perceived value and impact of SPD methods and tools

The consultants perceived that transformative change rarely occurs overnight, but rather cumulative: *"Dozens of incremental changes can produce a radical change. So, it's never radical at the beginning, but the radicality comes when you really change the mindset."* This process often involves a delay before momentum builds: *"Then we arrive to the point where it [the change] actually starts and then it's self-reinforcing. When one success brings another – you need to consider that there is normally a two-year delay."* These insights highlight the significance of SPD tools beyond short-term results as their real strength lies in creating the foundations for sustained long-term transformation.

SLCA often served as an entry point to create a shared language and coordinate roles and supply-chain actors. One illustrative case involved an olive oil producer that rethought its packaging from a life-cycle perspective, replacing plastic coatings with biodegradable alternatives, using non-toxic inks, and local sourcing to reduce transport. These actions delivered concrete benefits such as cost savings, marketing advantages, and stronger supplier relationships. Over time, SLCA became embedded in the company's processes, supporting training, internal communication, and sustainability reporting. Employees began applying the tool independently, and sustainability principles were integrated into everyday decision-making alongside cost and quality considerations. As one consultant reflected: *"They're also seen as leaders from competitors. So that's in my opinion a radical change because it is a change introduced in the industry itself."*

Despite such successes, consultants expressed that: *"the level of impact that we have achieved so far is not satisfying. We want to see more concrete and real change in the industry."* They pointed to multiple barriers: (i) difficulty communicating strategic relevance to senior management, leading to perceptions that sustainability work is an additional burden; (ii) time and resource constraints, as companies prioritize short-term deliverables and hesitate to commit to initiatives requiring significant effort with uncertain outcomes; (iii) low initial competence levels; (iv) sector-specific customization needs; (v) maintaining motivation and engagement; and (vi) limited external recognition or third-

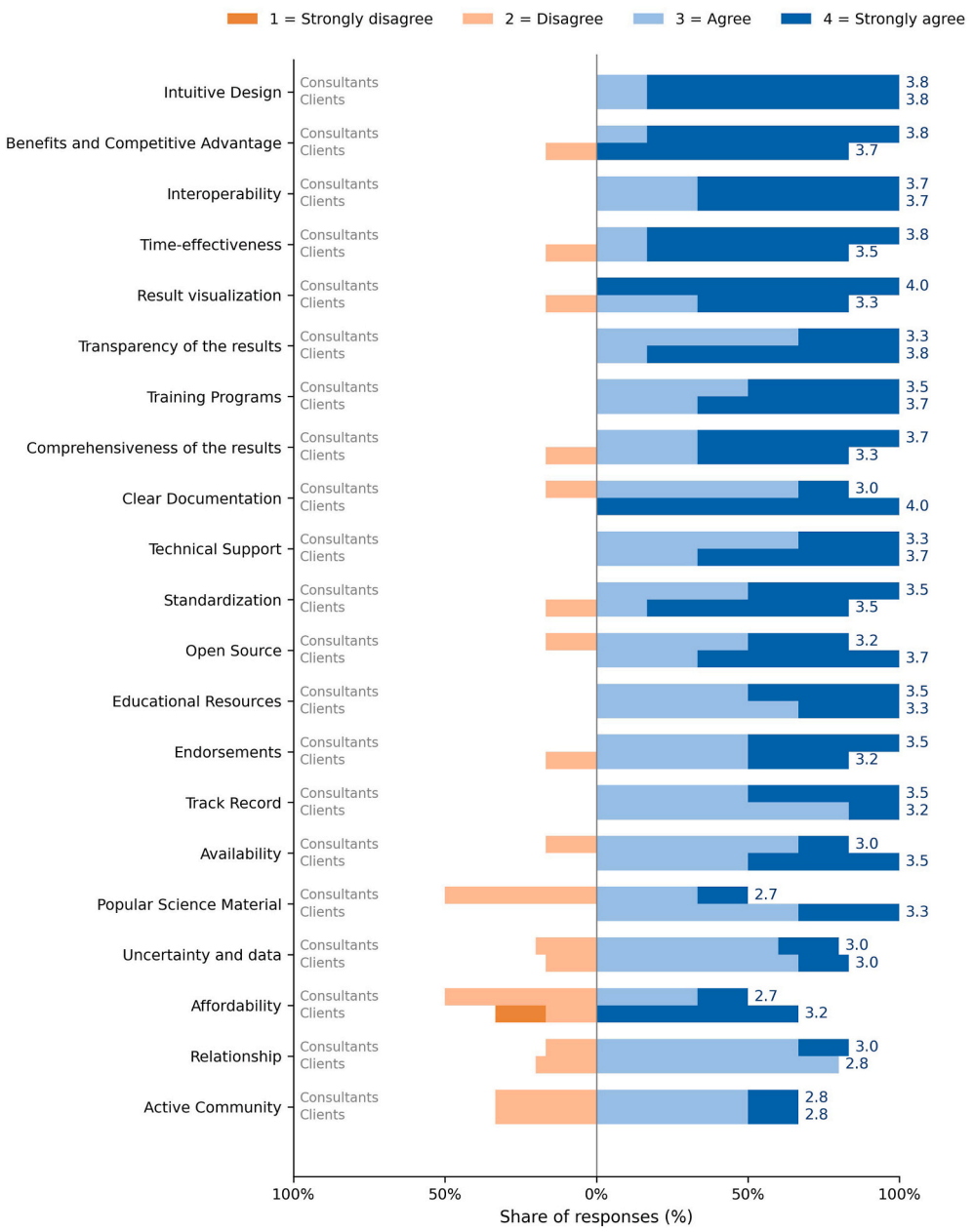

Fig. 2. Importance ratings for factors influencing the adoption and impact of sustainable product development methods and tools as perceived by consultants (n = 6) and clients (n = 6).

party verification, limiting opportunities to leverage results for marketing or compliance purposes.

4.1.3. *Academia-consultancy interplay: complementarity and barriers*

For SPD tools to gain traction in industry, they need to combine scientific rigor with practical usability across diverse contexts. Interviews revealed that academia and consultancy play complementary roles in achieving this balance. Academic research provides methodological robustness, conceptual clarity, and credibility, while consultancies contribute sector-specific insights and the ability to translate theory into actionable steps. As one consultant put it: *"There's no one world without the other. We should strive to reinforce this kind of interface."*

Consultants highlighted strong incentives for academia–consultancy collaboration: access to cutting-edge research enhances credibility and enables solutions that go beyond compliance. Academia benefits from consultancies' industry reach and exposure to practical challenges. However, barriers remain, notably the speed mismatch: *"What takes one month in academia needs to take one day in a consultancy."* Another challenge is the trade-off between comprehensiveness and practicality, which requires difficult decisions about simplification without losing essential content.

4.1.4. *Consultants' future outlook for SPD practices*

Consultants described the coming decade as a critical window for companies willing to take leadership in the sustainability transition. They expressed optimism and anticipate an acceleration in the integration of sustainability into product development, driven by regulatory initiatives such as the EU Green Deal and the Digital Product Passport, as well as growing market expectations. SPD is expected to evolve from an add-on activity to a core business function, influencing decisions across design, procurement, manufacturing, and marketing, and embedding sustainability into everyday roles and financial and strategic choices.

Tools that combine qualitative and quantitative approaches were seen as essential for supporting strategic decision-making under

complexity. Consultants emphasized the need for methods that enable life-cycle thinking while remaining practical and adaptable. They foresee a growing demand for simplified yet robust tools that help companies navigate trade-offs and design products with a systems perspective: *"You need tools that help make good decisions. And I think that sustainable product development tools are really crucial in the next 5 or 10 years in order to satisfy and be coherent with all the carbon objectives that the companies already set."* Digitalization and AI were highlighted as opportunities for improving usability and efficiency, provided they are supported by accurate data and implemented with care to preserve methodological integrity.

4.2. Application and impact of sustainable product development tools in industry

This section shifts to the client perspective, focusing on their experiences with applying SPD tools, impact pathways, and the conditions that influenced these outcomes.

4.2.1. Drivers and expectations

Clients described that they engaged with NATIVA to obtain a holistic, systematic approach that goes beyond single metrics such as CO_2 emissions. Several clients emphasized that existing tools were considered insufficient for their ambitions: *"we looked at what the market offered and realized that at that time, for the [sector], there was nothing structured. Even today, I don't think there's anything as complete as what we were aspiring to."* This sentiment reflected a broader expectation that the applied method would provide a comprehensive view of sustainability, covering ecological and social aspects while connecting to business strategy.

This choice was reinforced by strategic fit as the methodology aligned with organizational values and long-term visions (e.g., B Corp certification) and was seen as a way to *"transfer what we were doing at the organizational level to the product level,"* helping teams *"rethink the product for long-term sustainability"*. This alignment was perceived as essential for embedding sustainability into core business processes rather than treating it as an add-on. Clients also emphasized the credibility of academically grounded tools and NATIVA's "*competence, professionalism, and a scientific, methodological eye that is hard to find*". Beyond technical expertise, clients valued the collaborative mode in which NATIVA acted as an *"extended team"*, instead of imposing a standard methodology. This flexibility and willingness to customize the process were considered essential for ensuring relevance and acceptance within the organization.

The choice of SPD over more conventional approaches like LCA was linked to the strategic orientation and usability of the method. Clients valued that the approach enabled early-phase decision-making and cultural change by engaging multiple roles across the organization: *"for us, the great value wasn't just in evaluating development and providing guidance, but in creating a tool that would enable cultural change. While applying a vertical tool requires a specialist with specific skills, what we developed together is more transversal. It can be used by non-specialists and therefore has an impact on cultural change."* Others emphasized that the qualitative nature of the method made it less overwhelming than purely quantitative assessments, while still offering a structured basis for identifying improvement areas and guiding subsequent analyses: *"the SLCA underpins the LCA, as it influences how you conceive and design your product, which then impacts the data collected within the LCA."*

Expectations on applying SPD tools varied but often centred on practical guidance and internal communication across levels: *"a communication tool […] to show what was happening, how the product was evolving, and how the approach to sustainability was evolving."* Others expected the method to help identify priority areas and to make sustainability a guiding factor in design decisions: *"we expected to obtain practical tools that would help us make more informed decisions, but also to raise awareness among our team on all issues related to sustainability."* Some clients also anticipated reputational benefits with external stakeholders.

4.2.2. Application context and continued use

The application of SPD tools typically involved multiple roles and processes. Work was anchored in product development and R&D but often extended to operations, purchasing, and quality, with ESG/sustainability teams coordinating activities to ensure strategic alignment. Several clients described a broad engagement across technical and managerial roles: "*the whole company was involved […] from management down to production […], moving everyone towards a single direction.*"

Product selection was generally guided by portfolio importance and market position. Priority was often given to best-selling products or those with the highest production volumes, as these were perceived to have the greatest potential impact. In other cases, representative products were chosen to serve as pilots with the ambition to later extend the approach to the full portfolio.

Continued use of the tools varied. Some clients reported that they had integrated the methods into ongoing processes and were using them autonomously with the goal for "*these tools to become part of our daily process*". Others were still in early adoption or had paused their application due to external factors such as shifting market demands or regulatory complexity: "*currently, the tool is in a standby phase. This is not so much due to its technical nature or function, but rather to the complex issue of external communication.*" Others noted that the market had moved toward carbon-focused analyses, leading them to develop their own tools tailored to those requirements.

4.2.3. Industrial impact: type, magnitude, permanence, and success factors

Perceived impacts varied across clients and included tangible product and packaging improvements and emission reductions; Fig. 3 summarizes aggregated ratings, while Table 3 provides a cross-case analysis. While multiple clients found it difficult to quantitatively rate the level of impact, a change in mindset and culture was consistently emphasized as the most profound and long-lasting effect. Cost-saving effects were generally rated low, indicating sustainability was viewed primarily as an enabler for innovation and competitiveness.

Beyond mindset, respondents reported greater organizational awareness and a broader life-cycle understanding of product impacts. The method helped visualize the entire system and clarify improvement opportunities: "*the SLCA has given us greater awareness of the product's impact in its different life phases. Usually, a manufacturing company focuses on reducing its impact within its own gates. We hadn't pushed ourselves much beyond our gates […] this methodology helped us to realize the overall impact.*" This systemic perspective was often accompanied by stronger engagement across functions, creating a sense of ownership and motivation.

The nature of change was often described as *"incremental for operational solutions, but radical in the very change of mentality and design approach.*" Several clients stressed that the methodology introduced a new way of thinking about design decisions, shifting sustainability from a peripheral concern to a guiding principle. One client reflected that "*we continue to do the things we did before, but with a different awareness*," illustrating how the approach influenced decision-making even when core processes remained unchanged. Success factors included contextual tailoring, clear purpose and governance, visible leadership support and champions, and scalability across products and portfolios. The ability to combine strategic framing with practical usability was viewed as essential for embedding sustainability into everyday decision-making. The survey results, Fig. 2, revealed that the clients perceive intuitive design, clear benefits and competitive advantage, interoperability, access to training programs as important factors for SPD tool adoption. While these were aligned with the perceptions by consultants, clear documentation, open source, availability, and popular science material received higher ratings by clients than consultants. The opposite is true for the importance of result visualization and comprehensiveness of the results. Free-text responses from the clients further emphasized (i)

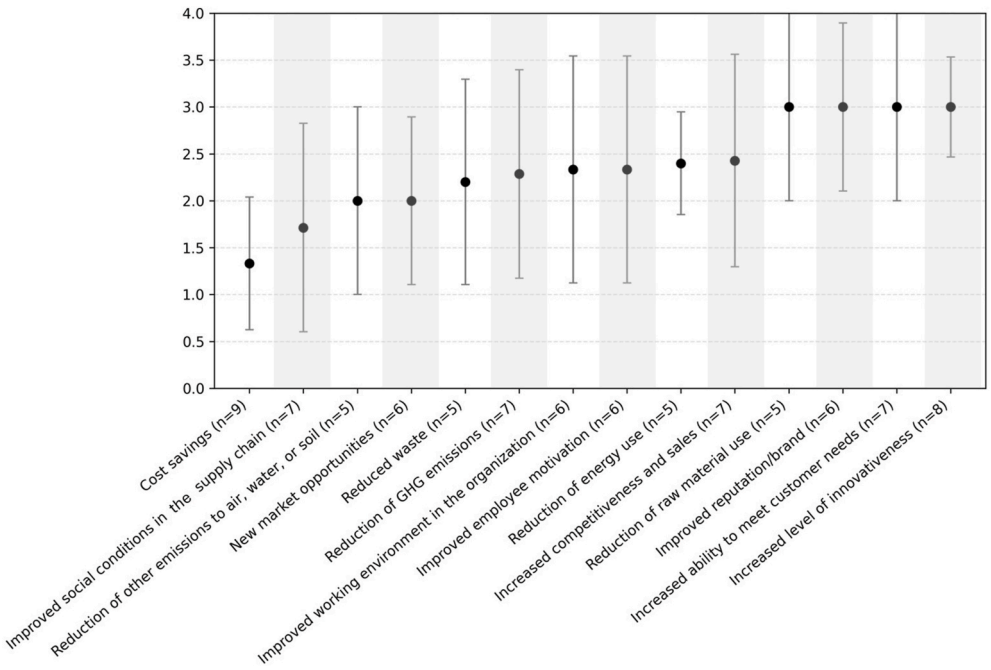

Fig. 3. Impact of SPD tool application perceived by clients, ranked from 1 = low impact to 4 = high impact. Dots display mean values and bars standard deviation. Items are ordered from lowest (left) to highest (right) mean value.

Table 3
Cross-case analysis of client-reported impacts from SPD tool application. For confidentiality reasons, cases (A–L) are not ordered to correspond to Table 2.

Case	Impact focus: cognitive/cultural (C); organizational/decision-making (O); technical/measurable (T)	Claim strength/type	Quantitative indicator	Impact monitoring/follow-up	Influencing conditions
A	**C + O + T:** identity and culture (C); organizational commitment and internal alignment (O); material substitution and product changes (T)	**Concrete examples:** cultural framing; material selection	**Not reported**	**Ongoing**	Consumer education; end-of-life system constraint; traceability constraint; supplier collaboration; regulations
B	**C + O + T:** life-cycle awareness beyond "own gates" (C); organizational alignment around priorities (O); specific packaging/material actions (T)	**Concrete examples:** multiple projects/actions described; quantified examples stated	**Reported**	**Work on hold**	Measurement/verification capability; "outside gates" framing.
C	**C + O + T:** radical change in mindset (C); organizational communication (O); incremental operational changes (T)	**General reported:** perceived engagement and design approach	**Not reported**	**Not reported**	Strategic vision; people engagement; systemic approach
D	**C + O + T:** culture change (C); organizational communication and decision making (O); incremental product change (T)	**General reported:** culture/mindset change stressed; product change incremental	**Not reported**	**Not reported**	Difficulty documenting/measuring impact explicitly stated; importance of leadership highlighted
E	**C + O + T:** holistic reframing (C); prioritization clarity (O); process optimization; waste management (T)	**General reported:** clarity/order; internal use emphasized	**Not yet**	**Planned**	Standby due to external communication/greenwashing risk and evolving regulation
F	**C + O + T:** reframing of sustainability (C); early-stage integration into daily process (O); packaging and material actions (T)	**Concrete examples:** packaging optimization; decision changes	**Not reported**	**Planned**	Supplier feasibility/availability and price constraints; gradual change logic
G	**C + O:** visibility, awareness, mindset (C); governance and role coordination (O)	**General reported:** governance important; learning curve for sustainability language	**In process**	**Planned**	Governance/leadership; terminology learning curve
H	**C + O:** Cognitive reframing and different awareness (C); cross functional dialogue (O)	**General reported:** incremental awareness; frustration with room for manoeuvre	**Not attributable**	**None**	Market shift towards carbon analysis; value-chain constraint (work to others' specifications)
I	**C + O:** engagement (C); design process changes (O)	**General reported:** ongoing use; building designer-facing approach	**Not reported**	**Not yet**	Primary data availability challenge; regulatory pressure for earlier calculation in design
J	**C + O + T:** strategic reframing (C); structured supplier engagement and working groups (O); logistic and packaging initiatives (T)	**Concrete examples:** supplier working groups; packaging changes	**Not reported**	**Planned**	Supplier engagement/working groups; scope-3/reporting pressure
K	**C + O:** Cognitive reframing and awareness (C); routines, procedural screening behaviour (O)	**General reported:** prioritization behaviour and tracking ambitions described	**Not reported**	**Not reported**	Organizational conditions and leadership; internal competitiveness driver
L	**C + O + T:** strategy and vision framing (C); planning and supply chain decision-making (O); operational/process rationalization (T)	**Concrete examples:** local sourcing; transport rationalization	**Not yet**	**Planned**	Strategy-level sustainability vision; supply chain collaboration; external shocks

transparency of calculations to ease external verification and auditing; (ii) keeping tools easy to learn and apply; and (iii) making tools adjustable to the user's knowledge and skill level.

4.2.4. Challenges and barriers for impact

While the application of SPD tools was generally perceived as valuable, several challenges and limitations were reported, reflecting both technical and organizational dimensions. A recurring issue concerned the complexity of the methodology and the effort required to collect "*precise, punctual information*", which slowed progress. These difficulties were often short-lived but highlighted the resource intensity of the approach. Data-related challenges extended beyond the effort of collection. Clients pointed to the difficulty of integrating sustainability data into existing information systems and the need for awareness of data quality: *"Impure data is still data … you have to know that data is average data and take it with the right awareness."* This recognition underscored the tension between the desire for precision and the practical realities of working with incomplete or imperfect datasets.

A second set of barriers concerned translation to action and locus of control: "*the complexity of the tool lies in its very high level, making it difficult to always translate it into something concrete and specific to our sector*." This challenge was particularly evident when improvement opportunities were identified in areas with limited influence, such as upstream supply chains. In such cases, the inability to act on identified hotspots led to frustration: "*evaluating impacts that we didn't fully understand how to change or where we had very little room for manoeuvre*."

Beyond these technical aspects, clients considered the cultural dimension to be the most significant challenge. Sustainability was *"a mindset,"* requiring cross-functional collaboration and sustained engagement. Several companies reported difficulties in *"making it a truly collaborative effort and keeping people from different departments engaged and working synergistically."* Achieving this level of engagement was seen as essential for embedding sustainability into everyday practices, yet it demanded time and persistence: *"Change does not happen overnight … it's a continuous process that requires constant commitment and a long-term vision."*

Related to this cultural dimension was the challenge of aligning expectations internally and externally. Interviewees noted that colleagues unfamiliar with sustainability sometimes struggled to see the relevance of the work. Language and communication were also mentioned as obstacles in this context. The academic origin of the tool occasionally created a gap between methodological framing and industrial practice: "*it's the challenge of moving from an academic language to an industrial one. This difficulty could undermine the tool's credibility, especially for those not familiar with sustainability daily*." The complexity of the tool and the lack of formal recognition or third-party verification was seen as limiting the tool's usefulness for external communication and marketing: *"we did suffer a bit from the fact that it wasn't a widely recognized tool externally – explaining what our work entailed was a bit more complex."*

External factors also constrained implementation. Some clients faced market conditions that prioritized carbon-focused analyses, reducing the perceived need for broader SPD approaches. Others encountered barriers in the supply chain, where *"it was not always easy to find immediate solutions that are suitable for our type of product and available at an accessible price."* In certain cases, suppliers were unable or unwilling to adopt requested changes, illustrating how technological readiness and capacity limitations can slow progress. Finally, clients noted that consumer behaviour and regulatory complexity added further layers of difficulty. While regulations were seen as a driver of future adoption, their current form was described as *"extremely complex"* and sometimes detached from industrial realities.

4.2.5. Clients' future outlook for SPD practices

Clients consistently anticipated that SPD will become a mainstream practice over the next decade, moving from a niche practice to an integral part of industrial operations: *"sustainability will become an integral part of the development and management of products, just like quality and safety"* forming a *"third leg of that structure that must* support *the credibility of our products"*. Design roles were highlighted as particularly crucial: *"A tool is needed that calculates the environmental and social impact at the moment the designer chooses the materials and decides how to create the design. Otherwise, it all becomes a reporting exercise and not a tool for the designer."* Clients also foresaw growing demands for data integration and knowledge-sharing, as well as attention to biodiversity and end-of-life considerations.

Regulation was viewed as a primary driver. Although some expressed frustration that *"legislators [are] so detached from reality,"* clients agreed that the long-term direction is clear and expected regulation to facilitate broader sectoral collaboration. Market dynamics were also expected to shift, with sustainability becoming a baseline rather than a differentiator. Some clients predicted a transition from *"compulsive, trend-driven, emotional purchase"* to *"a purchase more driven by values,"* rewarding companies that embed sustainability into their brand. However, several stressed that SPD alone will not suffice: *"We must manage to trigger degrowth trends."* This reflects a belief that systemic change in production and consumption patterns is necessary alongside product-level improvements.

5. Discussion

Read together, the consultant and client perspectives help reconcile two tensions highlighted in literature: reviews frequently note that studies report adoption or process outputs but rarely verified, realized outcomes (Schäfer and Löwer, 2021; Pigosso et al., 2015). At the same time, method-transfer literature encourages evaluation of design methods not only for conceptual rigor but also for usability, customizability, and fit to practice in a broader "method ecosystem" (Gericke et al., 2020; Küçüksayraç et al., 2015; Koria et al., 2022; Mallalieu et al., 2024). The consultancy evidence clarifies upstream translation mechanisms and adoption/adaptation enablers, while the client cases illustrate how reported outcomes vary with organizational and larger system conditions.

5.1. From organizational impact to system-level change: pathways, conditions, and limits

The empirical evidence in this study consistently indicates cognitive and cultural impact, e.g., mindset change, shared language, and organizational-level impacts, such as cross-functional dialogue, and new routines for prioritization and supplier engagement. In contrast, evidence of material and emission reductions, i.e., the outcomes that ultimately determine progress toward sustainability, was more limited. Such changes were found difficult to realize at speed because firms are constrained by their position in the system and by external mechanisms beyond their immediate control (Dekoninck et al., 2016; Vilochani et al., 2024). System-level change is therefore rather a potential downstream pathway that may follow when enabling conditions beyond tool use are present and intentionally developed.

The findings thus point to a multi-layered and time-phased pattern of impact, see Fig. 4. Across cases, SPD tool impacts were primarily cognitive and cultural (e.g., reframing what sustainability means in concrete product terms) and in many cases formalized through decision-making process changes (e.g., routines for hotspot prioritization and multi-role engagement). These effects were comparatively consistent across cases and align with the view that implementation success depends not only on methodological soundness, but also on usability, organizational fit, and decision support under industrial constraints (Dekoninck et al., 2016; Gericke et al., 2020; Peace et al., 2018). Downstream technical and measurable outcomes emerged more selectively, with a time delay, and tended to depend on additional organizational and external enabling conditions (Hallstedt et al., 2023a; Schöggl et al., 2024; Vilochani et al., 2024). This does not imply that

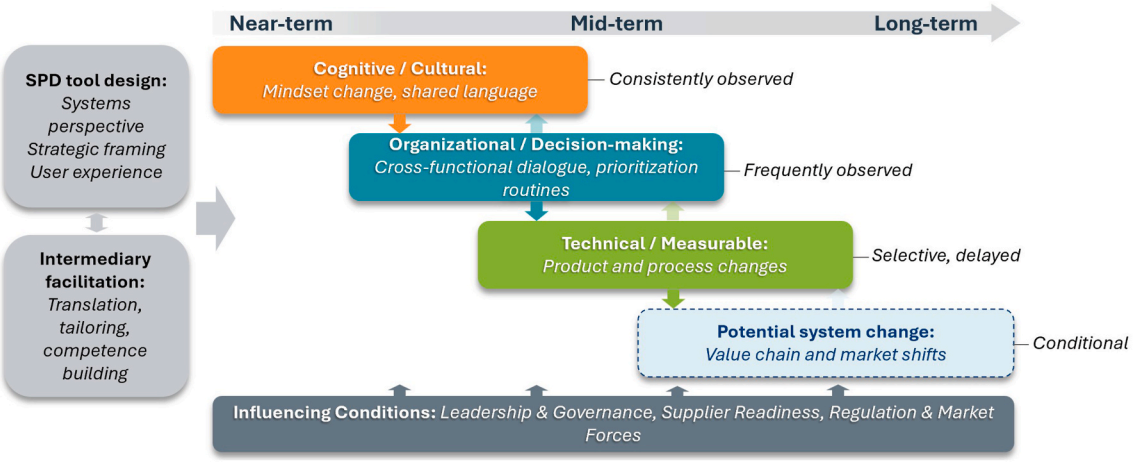

Fig. 4. The multi-layered, time-phased impact pathways, their grounding in the empirical data, and examples (in italics).

organizational effects are merely "soft" or secondary. It may be argued that system-level change often begins through reproducible shifts in what designers, engineers, and managers attend to, how early decisions are structured, and how dialogue with suppliers and customers is conducted, which can cascade outward over time (Boks, 2006; Brones et al., 2017). However, the findings indicate that such cascades are unlikely to materialize at scale without additional conditions. Mindset shifts and organizational alignment thus appear necessary yet insufficient as they can create direction and coordination capacity, but do not automatically dissolve structural constraints such as value chain lock-in, supply-chain capability gaps, or diverging external expectations for evidence and communication (Peace et al., 2018; Spigarelli et al., 2025; Vilochani et al., 2024).

From this perspective, the practical role of current SPD tools is more accurately described as enabling alignment, prioritization, and credible early-phase decision support, rather than functioning as single levers for whole-system redesign (Gericke et al., 2020; Peace et al., 2018). To address these dynamics explicitly, three interacting sources of influence can be differentiated. First, tool characteristics (e.g., system view, strategic framing, visualization) support cognitive reframing and prioritization by making trade-offs discussable and by structuring early decisions. Second, intermediary facilitation (consultancy translation, tailoring, convening of roles, and competence building) supports uptake and embedding by adapting tools to the client's method ecosystem and language, and by sustaining engagement beyond one-off training, supported by internal process structures (Höpfl et al., 2026; Küçüksayraç et al., 2015; Koria et al., 2022; Peace et al., 2018). Third, wider contextual drivers (leadership and governance, regulation and market pressure, supplier readiness) largely determine whether organizational alignment translates into durable product, portfolio, or supply-chain outcomes (Dekoninck et al., 2016; Brones et al., 2017; Schöggl et al., 2024). The implication is that SPD tools can play an important enabling role in pathways toward system innovation, but they are unlikely to be sufficient on their own. If system innovation for sustainability is the desired effect, the findings suggest that early-phase SPD tools should be paired with deliberate work on enabling conditions. Such a pairing may be the most plausible route by which mindset change can be further converted into tangible product and process outcomes over time (Schäfer and Löwer, 2021; Gericke et al., 2022; Hallstedt et al., 2023a, 2023b).

5.2. Multi-actor recommendations

Based on the impact pathway and enabling conditions synthesized in Section 5.1, seven multi-actor recommendations are proposed, which may serve as guidance for researchers, intermediaries, and companies.

Build a shared language early: Common language is the first step toward cultural alignment. Consultants can use sensemaking workshops to clarify sustainability principles and process logic, reducing resistance and fostering ownership. Clients need to create coherence with corporate vocabulary to avoid perceptions of sustainability as an abstract or imposed agenda. Researchers can support this by providing plain-language materials, visual templates, and examples that ease translation across roles.

Combine qualitative framing with targeted quantitative proof: Qualitative assessments set direction; quantitative indicators provide credibility and monitoring. Consultants should keep complexity low while guiding where deeper analysis is needed. Clients should recognize that "imperfect but aware" data is better than none, provided its limitations are understood. Researchers should publish indicator sets, data schemas, and uncertainty guidance to enable responsible use of partial data.

Stage the change – quick wins first, capability building always: Cultural change is the foundation for SPD adoption. Consultants should strive for visible results to build momentum and trust, while providing training to foster autonomy. Clients should start small and scale deliberately, combining top-down leadership with bottom-up engagement. Researchers should embed onboarding flows and reflection checkpoints into method design to help organizations track cultural progress even when quantitative metrics are incomplete.

Orchestrate cross-functional and supply-chain collaboration: For impacts to scale, SPD requires engagement across roles and value-chain actors. Consultants should leverage shared platforms and visual outputs to coordinate simultaneous work and make results accessible. Clients need to structure supplier dialogues and pace ambitions with feasibility. Researchers should design methods for multi-actor workflows and provide interoperable support that fits company information systems.

Communicate credibly, inside and out: Clear language, visualization, and traceability enable internal buy-in and cautious external use. Consultants should involve marketing early and translate results into concise narratives. Clients should frame sustainability as a competitive advantage, not just a cost, and ensure coherence with corporate purpose. Researchers need to provide transparency in assumptions and alignment with reporting regimes to strengthen credibility and reduce greenwashing risks.

Co-create across the interface and iterate: Joint development and piloting align rigor with practicality and speed. Consultants need to feed usability constraints and sector nuances back to researchers. Clients should adapt tools collaboratively for increased ownership. Researchers should conduct action research and iterative pilots to reconcile academic thoroughness with industrial timelines.

Keep the systemic view – connecting product decisions to broader impacts: Product-level improvements must be complemented by broader shifts in production and consumption systems. Consultants can help frame trade-offs and limits, guiding clients toward realistic ambitions that gradually lead towards long-term success. Clients should avoid "doing everything at once" and strive for stepwise progress while advocating systemic change. Researchers should connect method guidance to portfolio-level decisions and articulate boundaries to avoid overpromising, while maintaining a long-term strategic view.

6. Conclusions

This study examined how sustainable product development (SPD) tools move from academic development via intermediary uptake to industrial application and impact, using a multi-actor, multiple-case design that combined an embedded consultancy case with cross-sector client cases.

For RQ1 (success factors for consultants to adopt and adapt academically developed SPD tools), the findings indicate that adoption is facilitated when tools are proven useable and time-effective in early phases, offer clear visualization and credible traceability, and are customizable to sector language and routines. This pattern lends empirical support to calls to evaluate methods not only for conceptual rigor but also for usability and integration within a broader "method ecosystem". For RQ2 (what types of industrial impacts arise and under which conditions), the results indicate a multi-layered and time-phased pattern of impact in which reported near-term outcomes were most consistently reported in culture and mindset, cross-functional dialogue, and prioritization, whereas more technical and measurable changes in products, processes, and portfolios emerged more selectively, with time delay, and depended on enabling conditions such as governance, supplier capability and openness, verification environments, and policy and market signals. These conditions extended beyond tool characteristics and included intermediary facilitation and wider contextual drivers (e.g., leadership, regulation, and market pressure). System-level change is therefore not presented as an observed outcome of SPD tool application in the present dataset, but is rather a potential downstream pathway when SPD tool use is paired with deliberate work on enabling conditions for translation across supply chains and markets.

In light of the urgency of the sustainability challenge, the findings raise the question of whether the impact of SPD tools is enough. Mindset shifts are necessary but insufficient if they do not lead to corresponding changes in the design of product and production systems. If system innovation for sustainability is the desired longer-term outcome, current SPD tools do not suffice on their own but play an important role for transforming company culture, creating alignment, and deciding on priorities, from which change may cascade along supply chains and markets – if conditions are intentionally developed. This can be done by companies and supported by consultants but also underscores the importance of other actors like policy-makers, NGOs, industrial networks, and others.

The study contributes theoretically by extending method-ecosystem accounts with a multi-actor, time-phased explanation that links intermediary adoption enablers to impact pathways, and by identifying conditions that shape whether early organizational impacts translate into more material outcomes. The study contributes practically by offering actionable recommendations for consultants, companies, and researchers on designing, translating, and embedding tools to maximize impact. This study's limitations are that it draws on a single consultancy network and a subset of SPD tools within a specific geographical context, relies primarily on self-reported client outcomes, and lacks longitudinal quantitative performance tracking. Generalizability is therefore bounded and causal attributions for long-term effects remain tentative. While consistently observed in the cases in this study, the layered and time-phased impact pathway should therefore not be understood as a universal model of impact formation. Future research should focus on support for system innovation: designing and testing configurations where SPD tools are deliberately paired with enabling mechanisms such as supplier-capability building, verification interfaces that lower communication risk, and alignment with policy and market signals.

CRediT authorship contribution statement

Jesko Schulte: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Sophie I. Hallstedt:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – review & editing. **Matilda S. Watz:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – review & editing. **Irene Lo Vecchio:** Conceptualization, Data curation, Investigation, Resources. **Matteo Caprioli:** Conceptualization, Data curation, Investigation, Resources. **Silvia Zanazzi:** Conceptualization, Data curation, Investigation, Resources.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Irene Lo Vecchio, Matteo Caprioli and Silvia Zanazzi are employees of NATIVA S.r.l. SB, the consultancy that served as the embedded case in this study. NATIVA facilitated access to participants in dialogue with the academic researchers and conducted client interviews using a protocol developed by the researchers. All transcripts and other data were independently analyzed by the academic authors, who had full access to the data and final responsibility for interpretation and publication. The other authors declare no competing interests.

Acknowledgements

This research was funded partly by the Knowledge Foundation, Sweden, through the Sustainable Product Innovation for Rewarding Transformation (SPIRIT) Synergy Project (contract 20240015), GENIE - Gender Initiative for Excellence, and Chalmers Production Area of Advance at Chalmers University of Technology. Sincere thanks to the interviewees and participating companies: Capua 1880 S.r.l., Chiesi Farmaceutici S.p.A., C.P. Company, Eurotherm S.p.A., Faba S.r.l., Florim Ceramiche S.p.A., Focchi S.p.A., F.lli Saclà S.p.A., Kerakoll S.p.A., OVS S.p.A., Slowear S.p.A., Victorinox AG. The contribution of Alessandra De Santi and Samira Tasso to this research is gratefully acknowledged.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2026.148906.

Data availability

The data that has been used is confidential.

References

Baldassarre, B., Keskin, D., Diehl, J.C., Bocken, N., Calabretta, G., 2020. Implementing sustainable design theory in business practice: a call to action. J. Clean. Prod. 273, 123113. https://doi.org/10.1016/j.jclepro.2020.123113.

Baumann, H., Boons, F., Bragd, A., 2002. Mapping the green product development field: engineering, policy and business perspectives. J. Clean. Prod. 10 (5), 409–425. https://doi.org/10.1016/S0959-6526(02)00015-X.

Benn, S., Edwards, M., Williams, T., 2018. Organizational Change for Corporate Sustainability, fourth ed. Routledge.

Bhamra, T., Hernandez, R.J., 2021. Thirty years of design for sustainability: an evolution of research, policy and practice. Design Science 7. https://doi.org/10.1017/dsj.2021.2.

Boks, C., 2006. The soft side of ecodesign. J. Clean. Prod. 14 (15–16), 1346–1356. https://doi.org/10.1016/j.jclepro.2005.11.015.
Brezet, H., van Hemel, C., 1997. Ecodesign: a promising approach to sustainable production and consumption. United Nations Environment Programme, Industry and Environment, Cleaner Production.
Broman, G.I., Robèrt, K.-H., 2017. A framework for strategic sustainable development. J. Clean. Prod. 140, 17–31. https://doi.org/10.1016/j.jclepro.2015.10.121.
Brones, F.A., de Carvalho, M.M., de Senzi Zancul, E., 2017. Reviews, action and learning on change management for ecodesign transition. J. Clean. Prod. 142, 8–22. https://doi.org/10.1016/j.jclepro.2016.09.009.
Burnes, B., 2015. Understanding resistance to change—building on coch and French. J. Change Manag. 15 (2), 92–116. https://doi.org/10.1080/14697017.2014.969755.
Byggeth, S.H., Broman, G.I., Robèrt, K.-H., 2007. A method for sustainable product development based on a modular system of guiding questions. J. Clean. Prod. 15 (1), 1–11. https://doi.org/10.1016/j.jclepro.2006.02.007.
Byggeth, S.H., Broman, G.I., 2001. Environmental aspects in product development: an investigation among small- and medium-sized enterprises. Proceedings of SPIE J. Environ. Manage. 4193. https://doi.org/10.1117/12.417271.
Chatty, T., Harrison, W., Ba-Sabaa, H.H., Faludi, J., Murnane, E.L., 2022. Co-creating a framework to integrate sustainable design into product development practice: case study at an engineering consultancy firm. Sustainability 14, 9740. https://doi.org/10.3390/su14159740.
Creswell, J.W., Poth, C.N., 2017. Qualitative Inquiry and Research Design. SAGE Publications.
Dekoninck, E.A., Domingo, L., O'Hare, J.A., Pigosso, D.C., Reyes, T., Troussier, N., 2016. Defining the challenges for ecodesign implementation in companies: development and consolidation of a framework. J. Clean. Prod. 135, 410–425. https://doi.org/10.1016/j.jclepro.2016.06.045.
Eisenhardt, K.M., 1989. Building theories from case study research. Acad. Manag. Rev. 14 (4), 532–550. https://doi.org/10.2307/258557.
Faludi, J., Hoffenson, S., Kwok, S.Y., Saidani, M., Hallstedt, S.I., Telenko, C., Martinez, V. A., 2020. Research roadmap for sustainable design methods and tools. Sustainability 12, 8174. https://doi.org/10.3390/su12198174.
Flick, U., 2007. Designing Qualitative Research, fourth ed. SAGE Publications. https://doi.org/10.4135/9781849208826.
Flick, U., 2014. The SAGE Handbook of Qualitative Data Analysis. SAGE Publications. https://doi.org/10.4135/9781446282243.
Gericke, K., Eckert, C., Campean, F., 2020. Supporting designers: moving from method menagerie to method ecosystem. Design Science 6, e21. https://doi.org/10.1017/dsj.2020.21.
Gericke, K., Eckert, C., Stacey, M., 2022. Elements of a design method: a basis for describing and evaluating design methods. Design Science 8, e29. https://doi.org/10.1017/dsj.2022.23.
Guertler, M.R., 2018. How to design methods for application—empirical insights from industry. In: Marjanović, D., et al. (Eds.), Proceedings of the DESIGN 2018 15th International Design Conference. Cambridge University Press, pp. 1161–1172. https://doi.org/10.21278/idc.2018.0169.
Guest, G., Bunce, A., Johnson, L., 2006. How many interviews are enough?: an experiment with data saturation and variability. Field Methods 18 (1), 59–82. https://doi.org/10.1177/1525822X05279903.
Hallstedt, S.I., Isaksson, O., Nylander, J.W., Andersson, P., Knuts, S., 2023a. Sustainable product development in aeroengine manufacturing: challenges, opportunities and experiences from GKN aerospace engine system. Design Science 9, e22. https://doi.org/10.1017/dsj.2023.22.
Hallstedt, S.I., Villamil, C., Lövdahl, J., Nylander, J.W., 2023b. Sustainability Fingerprint—Guiding companies in anticipating the sustainability direction in early design. Sustain. Prod. Consum. 37, 424–442. https://doi.org/10.1016/j.spc.2023.03.015.
Hallstedt, S.I., Isaksson, O., 2017. Material criticality assessment in early phases of sustainable product development. J. Clean. Prod. 161, 40–52. https://doi.org/10.1016/j.jclepro.2017.05.085.
Hauschild, M., Rosenbaum, R., Olsen, S. (Eds.), 2018. Life Cycle Assessment: Theory and Practice. Springer. https://doi.org/10.1007/978-3-319-56475-3.
Höpfl, L., Dolezalek, P., Peter, C., Brem, A., Wirzberger, M., 2026. Strategies and recommendations for embedding sustainability in innovation and design processes. Sci. Rep. 16, 8483. https://doi.org/10.1038/s41598-026-42854-9.
Küçüksayraç, E., Keskin, D., Brezet, H., 2015. Intermediaries and innovation support in the design for sustainability field: cases from the Netherlands, Turkey and the United Kingdom. J. Clean. Prod. 101, 38–48. https://doi.org/10.1016/j.jclepro.2015.03.078.
Koria, M., Osorno-Hinojosa, R., Ramírez-Vázquez, D.d.C., van den Broek, A., 2022. One world, two ideas and three adaptations: innovation intermediaries enabling sustainable open innovation in university–industry collaboration in Finland, Mexico and Nicaragua. Sustainability 14, 11270. https://doi.org/10.3390/su141811270.
Lewis, H., Gertsakis, J., Grant, T., Morelli, N., Sweatman, A., 2001. Design + Environment: a Global Guide to Designing Greener Goods. Greenleaf Publishing.
Lofthouse, V., 2006. Ecodesign tools for designers: defining the requirements. J. Clean. Prod. 14 (15–16), 1386–1395. https://doi.org/10.1016/j.jclepro.2005.11.013.
Luttropp, C., Lagerstedt, J., 2006. EcoDesign and the 10 golden rules: generic advice for merging environmental aspects into product development. J. Clean. Prod. 14 (15–16), 1396–1408. https://doi.org/10.1016/j.jclepro.2005.11.022.
Mallalieu, A., Hallstedt, S.I., Isaksson, O., Watz, M., Almefelt, L., 2024. Barriers and enablers for the adoption of sustainable design practices using new design methods: accelerating the sustainability transformation in the manufacturing industry. Sustain. Prod. Consum. 51, 137–158. https://doi.org/10.1016/j.spc.2024.08.023.
Maxwell, J.A., 2013. Qualitative Research Design: an Interactive Approach, third ed. SAGE Publications.
Ny, H., MacDonald, J.P., Broman, G., Yamamoto, R., Robèrt, K.-H., 2006. Sustainability constraints as system boundaries: an approach to making life cycle management strategic. J. Ind. Ecol. 10 (1–2), 61–77. https://doi.org/10.1162/108819806775545349.
Orecchini, F., Valitutti, V., Vitali, G., 2012. Industry and academia for a transition towards sustainability: advancing sustainability science through university–business collaborations. Sustain. Sci. 7, 57–73. https://doi.org/10.1007/s11625-011-0151-3.
Peace, A., Ramirez, A., Broeren, M.L.M., Coleman, N., Chaput, I., Rydberg, T., Sauvion, G.N., 2018. Everyday industry: pragmatic approaches for integrating sustainability into industry decision making. Sustain. Prod. Consum. 13, 93–101. https://doi.org/10.1016/j.spc.2017.08.003.
Pigosso, D.C.A., McAloone, T.C., Rozenfeld, H., 2015. Characterization of the state-of-the-art and identification of main trends for ecodesign tools and methods: classifying three decades of research and implementation. J. Indian Inst. Sci. 95 (4), 405–428.
Rossoni, A.L., de Vasconcellos, E.P.G., de Castilho Rossoni, R.L., 2024. Barriers and facilitators of university–industry collaboration for research, development and innovation: a systematic review. Manag. Rev. Q. 74, 1841–1877. https://doi.org/10.1007/s11301-023-00349-1.
Schäfer, M., Löwer, M., 2021. Ecodesign: a review of reviews. Sustainability 13, 315. https://doi.org/10.3390/su13010315.
Schöggl, J.-P., Baumgartner, R.J., O'Reilly, C.J., Bouchouireb, H., Göransson, P., 2024. Barriers to sustainable and circular product design – a theoretical and empirical prioritisation in the European automotive industry. J. Clean. Prod. 434, 140250. https://doi.org/10.1016/j.jclepro.2023.140250.
Soares, J.C.C., 2024. *The Role of Private Consultants as Innovation Intermediaries in Technology Transfer* (Doctoral Thesis). Universidade do Minho. https://repositorium.uminho.pt/server/api/core/bitstreams/e90bd13f-3d1c-4161-ba27-cdf4057fa43b/content.
Spigarelli, F., Compagnucci, L., Lepore, D., 2025. Blockchain unlocking collaborative opportunities for environmental sustainability through innovation intermediaries. J. Technol. Tran. 50 (2), 516–551. https://doi.org/10.1007/s10961-024-10106-5.
Vilochani, S., Borgianni, Y., McAloone, T.C., Pigosso, D.C.A., 2024. An investigation into the extent to which sustainable product development practices are implemented in manufacturing companies. Sustain. Prod. Consum. 50, 155–167. https://doi.org/10.1016/j.spc.2024.07.022.
Vilochani, S., McAloone, T.C., Pigosso, D.C.A., 2025. Bridging the gap: exploring the effect of sustainable product development practices into product sustainability performance in manufacturing companies. J. Environ. Manag. 378, 124821. https://doi.org/10.1016/j.jenvman.2025.124821.
Wallace, K., 2011. Transferring design methods into practice. In: Birkhofer, H. (Ed.), The Future of Design Methodology. Springer, pp. 239–248. https://doi.org/10.1007/978-0-85729-615-3_21.
Yin, R.K., 2018. Case Study Research and Applications, sixth ed. SAGE Publications.
Zumach, K., Wehrend, S., Krause, D., 2025. Challenges in addressing sustainability within product development. In: Proceedings of the Design Society, 5. Cambridge University Press, pp. 901–910. https://doi.org/10.1017/pds.2025.10104. ICED25.