Customer-based sustainable product design: a data-driven approach

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Abstract

Purpose – Sustainable product design (SPD) is essential for promoting environmental and economic sustainability by integrating sustainability principles throughout the product design process. However, existing approaches often fail to effectively incorporate consumer values, leading to a misalignment between sustainable products and consumer expectations. Challenges such as the attitude–behaviour gap, difficulties in quantifying subjective consumer perceptions and the lack of robust methodologies to align diverse preferences with design attributes hinder sustainable product adoption. This study contributes to SPD research by identifying key consumer values, sustainable product attributes, and data-driven methodologies, culminating in an integrated framework for customer-based SPD.

Design/methodology/approach – A Systematic Literature Review of Scopus-indexed studies – selected for its multidisciplinary peer-reviewed coverage – refined 2,256 articles to 39 empirical studies using Boolean search strings combining sustainable product design and consumer-centric terms, followed by multi-criteria abstract and full-text screening. Qualitative content analysis was conducted in NVivo 14 using an *a priori* coding framework, iteratively refined to capture key themes. The study examines consumer assessments of consumption values, product attributes, and SPD methodologies. By integrating established theories and data-driven techniques, it systematically maps the interconnections between design dimensions, consumer values and product attributes.

Findings – The review identifies six consumer values (functional, social, emotional, epistemic, conditional and green) and seven product attribute groups (sustainability cues, eco-labels, country of origin, quality, price, after-sales services and design) influencing sustainable product adoption. The analysis reveals no universal hierarchy: functional value operates as a non-negotiable gatekeeper in durables and automotive contexts, while merging indistinguishably with green value in agri-food settings. Existing SPD research relies heavily on structured surveys and hypothetical scenarios, limiting real-world applicability. To address these gaps, this study proposes a data-driven framework integrating choice-based experiments, machine learning algorithms and sentiment analysis to optimise SPD by aligning product attributes with consumer expectations.

Research limitations/implications – The framework integrates consumer values with Mishra's (2016) design perception dimensions but treats sustainability as a separate element, potentially limiting holistic integration of aesthetics, functionality and sustainability in design decision-making. The SLR relies solely on Scopus, excluding built-environment and product–service system studies visible in other databases. The cross-sectional evidence base limits the tracking of dynamic consumer preference shifts over time. Cultural variation in value hierarchies and the magnitude of the attitude–behaviour gap across different regulatory and infrastructural contexts remains unaddressed. Longitudinal studies, multi-database searches and cross-cultural empirical validation across industries are recommended to enhance the framework's robustness and adaptability.

Practical implications – From a managerial standpoint, this framework provides an actionable blueprint for a demand-led innovation strategy, de-risking green investment. It iteratively maps qualitative insights and quantitative analytics to tailor offerings for specific market segments, identifying attributes for which customers will pay a premium or switch brands. This approach closes the attitude–behaviour gap by ensuring every sustainable feature delivers tangible consumer value, making the sustainable choice the superior choice. Beyond industry, these insights inform targeted public policy, helping firms convert regulatory compliance – such as the EU Right to Repair directive – into a competitive advantage and fostering a market-based sustainability transition.

Originality/value – This study's primary value is a holistic framework fusing consumer psychology, SPD attributes and data analytics into a demand-led innovation strategy. Drawing on 39 empirical studies, it provides

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a novel value-to-attribute logic revealing that value hierarchies and attribute distributions are highly context-dependent, varying systematically across product categories. Its systematic process moves from identifying values and linking them to attributes, to quantifying their relative importance through continuous improvement loops. Acting as a practical front-end to existing SPD toolkits such as LCA and design for sustainable behaviour, it advances prior reviews from descriptive cataloguing toward an explicit, actionable logic for customer-based SPD.

Keywords Sustainable innovation, Consumer perception, Eco-design, Consumer values, Data-driven design, Sustainable product design

Paper type Literature review

1. Introduction

Sustainable product design (SPD) is a central strand of eco-innovation (Rennings, 2000; Xavier *et al.*, 2017) that integrates environmental, economic, and social concerns across the product life cycle (Ahmad *et al.*, 2018; He *et al.*, 2020; Mengistu *et al.*, 2024), with growing emphasis on consumer values and adoption behaviours as triggers of product uptake (Pinkse and Bohnsack, 2021). Rising consumer demand for sustainability (Dyllick and Rost, 2017) and the broader transition from linear to circular economic models (Bocken *et al.*, 2016; Baldassarre *et al.*, 2020) jointly underscore the need for data-driven, user-centred SPD methodologies that systematically translate consumer insights into product decisions (Bakker *et al.*, 2014) in driving sustained behavioural change (Horani, 2020; Kramer, 2012).

Despite progress in SPD, consumer values remain difficult to integrate and measure during product design. A central challenge is the attitude–behaviour gap (Carrington *et al.*, 2010), which reflects the disjunction between consumers' pro-environmental attitudes and their actual purchasing decisions. The extent of this gap is itself contested. Research using actual purchasing data suggests that relying on self-reported intentions can exaggerate it: Moser (2016) found that environmental attitudes predicted self-reported green purchases but had no significant effect on real purchase behaviour across several product categories. Yet other work upholds the gap's robustness even with improved data — Auger and Devinney (2007) observed that even highly eco-conscious consumers often fail to translate attitudes into action, underscoring a genuine "word-deed" disconnect. Crucially, its magnitude is context-dependent: product availability, price, and social influence moderate the attitude–behaviour linkage, and making sustainable options more accessible has been shown to narrow the divide (Vermeir and Verbeke, 2006). The gap has also been linked to greenwashing scepticism, doubts about product effectiveness, and price sensitivity (Aibar-Guzmán and Somohano-Rodríguez, 2021). Theoretically, classic frameworks — the Expectancy-Value Model (Lee and Holden, 1999), the Theory of Reasoned Action (Fishbein and Ajzen, 1975), and the Theory of Planned Behaviour (Ajzen, 1991) — each illuminate part of this dynamic, yet evidence shows that personal values can bypass attitudes entirely and directly shape habitual purchase choices (Hauser *et al.*, 2013; Schäufele and Janssen, 2021), with ethical, environmental, and social values significantly enhancing green purchase propensity (Zhuo *et al.*, 2023; Ghazali *et al.*, 2018). Together, these strands indicate that narrowing the attitude–behaviour gap depends as much on the value structures consumers bring to purchase decisions as on the environmental credentials of the products themselves.

Equally important is a critical examination of methodologies for SPD and their treatment of consumer insights. Traditional eco-design tools — such as Life Cycle Assessment (LCA) and CAD-integrated ecodesign frameworks — are effective in quantifying environmental impacts but often treat consumer behaviour as secondary (Rossi *et al.*, 2016; Briem *et al.*, 2019). User-centred methods such as Kansei Engineering, Design Thinking, and Quality Function Deployment incorporate consumer data to shape product features and design choices, but are frequently criticised for lacking robust quantitative links to design outcomes; relatively few approaches connect consumer perceptions of sustainability with product features in a measurable way (Montecchi and Becattini, 2020; Daae and Boks, 2015; Gong *et al.*, 2022). This methodological divide has prompted calls for more data-driven and interdisciplinary approaches, while also

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raising the legitimate concern that purely data-centric models may overlook experiential and social dimensions of sustainable consumption (Montecchi and Becattini, 2020). In practice, persistent challenges in quantifying subjective perceptions, aligning diverse preferences with specific design attributes, and collecting robust data for modelling (Amjad *et al.*, 2023) reinforce the case for evidence-based approaches grounded in customer feedback as a means of reconciling sustainability priorities with consumer demands (Maior *et al.*, 2022).

In response to these research gaps, this study conducts a Systematic Literature Review (SLR) of Scopus-indexed articles focussing on SPD, consumer perceptions of sustainable products, and consumer value integration in product design. Three closely related aims guide the review: to clarify how sustainable product attributes and consumer value dimensions are conceptualised and operationalised in the SPD literature; to examine how they are distributed across different product and market contexts; and to use these insights to articulate an integrated, data-driven framework for customer-based SPD. The framework's distinctive contribution lies in its explicit value-to-attribute logic — translating multi-dimensional consumer values into concrete, marketable product attributes. While the underlying value dimensions are well established in consumer research, their integration with sustainable product attributes and design decision-making remains underdeveloped, and the study advances prior reviews (Geng *et al.*, 2020; Camilleri *et al.*, 2023; Marcon *et al.*, 2022) by moving beyond descriptive cataloguing toward an actionable design logic. In doing so, it offers a practical, supply-side route to addressing the attitude–behaviour gap and points to future research directions for extending the framework across industries.

2. Methodology

This study uses an SLR to examine consumer perceptions of SPD. Scopus was chosen as the primary database due to its extensive coverage of peer-reviewed journals across multiple disciplines (Mongeon and Paul-Hus, 2016). The search strategy followed guidelines from Camilleri *et al.* (2023) and Marcon *et al.* (2022), combining eco-design and sustainable product terms — "ecodesign," "sustainable product," "green product innovation" — with consumer-centric terms — "customer perception," "consumer preference," "purchase intention" — using Boolean operators. Articles were included based on three criteria: (1) explicit focus on consumer perceptions of sustainable product design, rather than sustainable products in general; (2) investigation of consumer values and external drivers incorporated into product design; and (3) use of data-driven methodologies to understand consumer perception and sustainable product attributes. Figure 1 illustrates the step-by-step screening strategy. The initial search identified 2,256 documents, refined to 2,218 after excluding non-English publications and to 1,711 after limiting to journal articles. Abstract and full-text screening for consumer-focused empirical methods reduced the pool to 185 documents, and applying the three inclusion criteria in full identified 39 studies for the final analysis.

3. Results

This section presents findings derived from the SLR and qualitative content analysis of the 39 selected scholarly papers, focussing specifically on consumer perceptions toward SPD. Qualitative content analysis was conducted using NVivo 14, facilitating systematic coding and organisation of data (Jackson and Bazeley, 2019). Figure 2 summarises the temporal distribution of the 39 studies included in the review. An *a priori* coding framework, guided by the research objectives, was developed and iteratively refined to capture key themes and patterns from the selected literature. The findings are categorised into three main thematic areas: (1) consumer assessment of sustainable product attributes, (2) consumer value dimensions influencing SPD, and (3) evaluation of data-driven approaches for measuring consumer perceptions. Each category is discussed in turn below.

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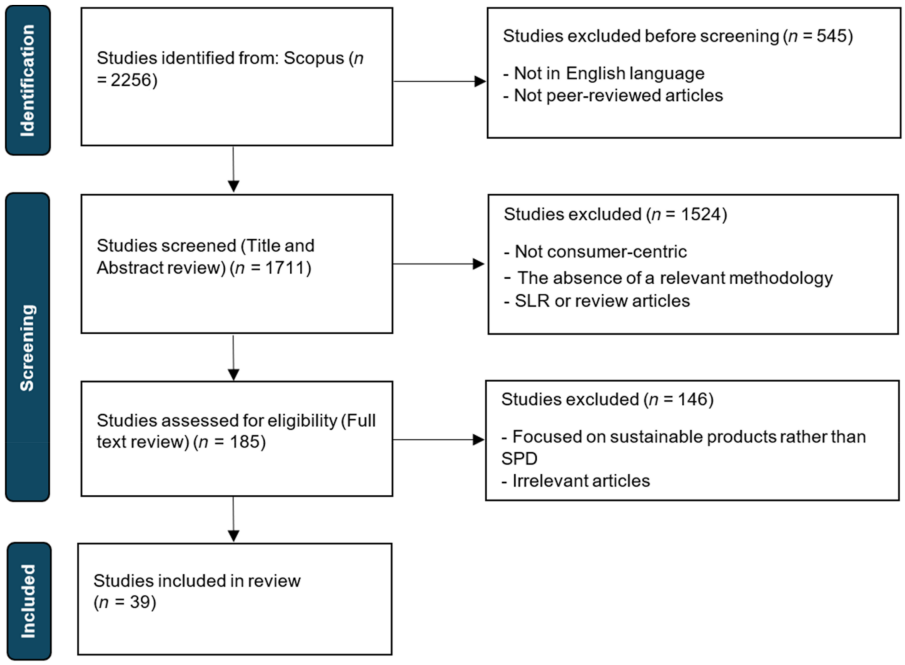

Figure 1. SLR process and protocols

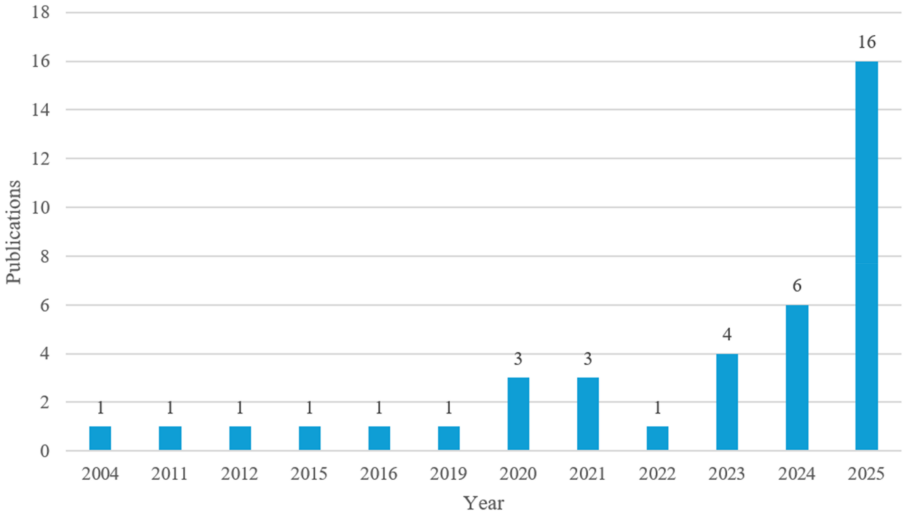

Figure 2. Distribution of publications by year in the systematic literature review ($n = 39$). **Note(s):** The chart shows the temporal evolution of research in sustainable consumption and green product design from 2004 to 2025. The data reveals three distinct periods: an early foundational period (2004–2016) with sporadic publications, a middle expansion period (2019–2022) with moderate growth, and a recent acceleration period (2023–2025) showing exponential increase in research output, with 2025 accounting for 41% of all publications in the review

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3.1 Consumer assessment of product attributes

The attributes of SPD significantly shape consumer acceptance and purchasing decisions (Ghazali *et al.*, 2023). Attributes such as quality, eco-labels, price, and country of origin are frequently decisive for environmentally conscious consumers (Aibar-Guzmán and Somohano-Rodríguez, 2021). Key product attributes identified from the literature that influence consumer adoption of sustainable products include sustainability cues, eco-labels and packaging, country of origin, quality and functional attributes, price sensitivity, after-sales services and design and aesthetic features. Tables 1–7 synthesise this evidence by grouping first-order attributes from the reviewed studies into broader second-order categories. This structure shows that consumer evaluation of sustainable products is shaped not only by environmental performance itself, but also by how that performance is communicated, validated, priced, supported, and embedded in the overall product experience. The following

Table 1. Sustainability cues, circularity and ethical production attributes

Second order attribute	First order attributes	Source papers
Circularity and end-of-life management	Recyclability, Material Recovery and Recyclable Design; Garment Life and Recycling; Longevity of Products; Eco-friendliness; Biodegradability; Reusability; Menstrual-cup; Recycling-based Solution	Bovea and Vidal (2004), Koszewska *et al.* (2020), Narassima *et al.* (2025), Balcıoğlu *et al.* (2025), Indrawati *et al.* (2025)
Environmental impact assessment and metrics	Graded Colour-Coded Environmental Impact Rating (A–G); Composite LCA-Based Environmental Impact Metric; Environmental Impact Disclosure; Carbon Footprint Label; Corporate Sustainability Signalling and Communication	Dihr *et al.* (2021), Li (2025), Paffarini *et al.* (2025), Zhang and Chen (2025), D'Adamo *et al.* (2024)
Material selection and resource efficiency	Surface Treatment Substitution (e.g. Powder Coating over Solvent-Based Coating); Biodiversity-friendly Product Assortment; Resource Efficiency Claims; Sustainable Water Use, Preserving Soil Fertility and Protecting Biodiversity; Material and Process Sustainability; Material Type (e.g. traditional, synthetic, or vegan leather)	Bovea and Vidal (2004), Foti *et al.* (2019), Wurster *et al.* (2020), Villanueva *et al.* (2025), Zhang and Chen (2025), D'Adamo *et al.* (2024)
Production process integrity and methods	Fishing Technique Disclosure; Lower Energy Consumption; Production Method (Organic vs. Conventional/Traditional); Production Process Circularity; Organic and Sustainability Labelling (Present vs. Absent); Environmental Impact and Animal Ethics; Reduced Carbon Footprint; Sustainability Label Type; Plastic Waste, Biowaste, GHG Emissions; Ethical Sourcing, Fair Production; Green Features and Eco-design of the Vehicle	Forleo *et al.* (2023), Bovea and Vidal (2004), Eldesouky *et al.* (2020), Koszewska *et al.* (2020), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Narassima *et al.* (2025), Vaikma *et al.* (2025), Villanueva *et al.* (2025), Balcıoğlu *et al.* (2025), Zhang and Chen (2025), Wijayatunga *et al.* (2024), Wallmo and Kosaka (2025)
Sustainability certification and standards	Eco-Label Presence; Eco-Friendly Ingredients Certification; Animal Welfare Label; Eco-label Claim; Certified; Sustainability Standard Integration; Eco-score	Dihr *et al.* (2021), Seo *et al.* (2016), Eldesouky *et al.* (2020), Li (2025), Huang *et al.* (2024), Wijayatunga *et al.* (2024), Shaikh *et al.* (2024)

Source(s): Authors' own elaboration

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Table 2. Packaging, eco-labels and information transparency attributes

Second order attribute	First order attributes	Source papers
Information display and communication systems	Cross-Category Normalised Comparison Capability; Scale Granularity (Multiple Tiers); Front-of-Pack Placement and Visibility; Label Presence (Label vs. Label-Free); Logo Design Format; Information System Granularity; Sustainability Information Dimensions; Information Accessibility and Clarity; Blockchain-based Traceability Label; Descriptive Carbon Footprint; Award Logo	Dihr *et al.* (2021), Kato *et al.* (2023), Borin *et al.* (2011), Wurster *et al.* (2020), Li (2025), Huang *et al.* (2024), Edenbrandt *et al.* (2025)
Information transparency and verification	Claim Specificity and Verifiability; Eco-label Presence and Informativeness	Nath and Agrawal (2023), Kumar and Basu (2023)
Labelling standards and compliance	Geographical Indication (PGI) Label; Environmental Labels and Certification on Clothing; Presence vs. Absence of Labels; Official Organic Certification	Lambarraa-Lehnhardt *et al.* (2021), Koszewska *et al.* (2020), Edenbrandt *et al.* (2025), Shaikh *et al.* (2024)
Visual communication and graphic design	Colour-Coded Environmental and Carbon Communication	Dihr *et al.* (2021), Forleo *et al.* (2023), Edenbrandt *et al.* (2025)
Sustainability of packaging materials	Reduced Packaging; Recycled Packaging; Returnable/Refillable Containers	Bovea and Vidal (2004), Seo *et al.* (2016), Narassima *et al.* (2025), Vaikma *et al.* (2025), Czine *et al.* (2025), Wijayatunga *et al.* (2024)
Packaging design elements and aesthetics	Cap and Bottle Shape and Style; Appropriate vs. Excessive Packaging Level	Kato *et al.* (2023), Seo *et al.* (2016), Wijayatunga *et al.* (2024)

Source(s): Authors' own elaboration

Table 3. Origin, local and ecosystem attributes

Second order attribute	First order attributes	Source papers
Geographic origin and regional identity	Country/Region of Origin Label; Geographic Origin Information; Territorial Identity and Regional Branding; Geographical Indication (PDO/PGI) Certification; Contribution to Rural Economy; Geographic Authenticity and Quality Claims	Forleo *et al.* (2023), Foti *et al.* (2019), Eldesouky *et al.* (2020), Li (2025), Paffarini *et al.* (2025), Villanueva *et al.* (2025), Czine *et al.* (2025), Wallmo and Kosaka (2025), D'Adamo *et al.* (2024)
Local production systems and manufacturing	Local/Domestic Production Claim or Label; Support for Local Economy and Small Producers; Local Production Systems; Locally Sourced	Lambarraa-Lehnhardt *et al.* (2021), Foti *et al.* (2019), Narassima *et al.* (2025), Wijayatunga *et al.* (2024)

Source(s): Authors' own elaboration

subsections discuss each attribute group and use the tables to clarify how individual design features contribute to customer-based SPD.

3.1.1 Sustainability cues. Sustainability cues such as durability, reparability, and eco-friendly materials drive consumer acceptance by extending product life, reducing environmental impact, and enhancing perceived sustainability (Koszewska *et al.*, 2020). Moreover, intrinsic sustainability cues, such as organic or eco-friendly ingredients, enhance

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Table 4. Functional performance and safety quality attributes

Second order attribute	First order attributes	Source papers
Performance quality and effectiveness	Functional Quality and Performance Delivery; Quality, Effectiveness and Efficiency; Tyre Performance; Nutritional Value and Impact on Health; Durability (paint quality, material durability, component longevity); Usage Convenience Design	Yuan *et al.* (2022), Nath and Agrawal (2023), Tsai *et al.* (2012), Wurster *et al.* (2020), Chaloupkova *et al.* (2025), Mitrache *et al.* (2025), Zhang *et al.* (2025), Balcıoğlu *et al.* (2025), Zhang and Chen (2025)
Physical properties and composition	High Juice-Content Metric (above threshold); Fruit Pulp Texture (Crisp-Firm); Presence of Pesticides, Formaldehyde, Plasticisers, and Recycled Materials; Food Ingredients (origin/base)	Lambarraa-Lehnhardt *et al.* (2021), Borin *et al.* (2011), Vaikma *et al.* (2025)
Safety, durability and structural integrity	Health and Food-Safety Emphasis for Biodiversity-Friendly Vegetables; Functional Durability and Quality; Absence of Harmful Elements	Foti *et al.* (2019), Koszewska *et al.* (2020), Narassima *et al.* (2025), D'Adamo *et al.* (2024)
Sensory quality and experience	Sensory Quality and Freshness Cues ("tasty", "fresher", "less treated"); Intrinsic Sensory Quality (Taste/Texture); Skin Colour (Dark Red)	Chaloupkova *et al.* (2025), Foti *et al.* (2019)

Source(s): Authors' own elaboration

Table 5. Price and economic attributes

Second order attribute	First order attributes	Source papers
Pricing strategy and market positioning	Cheaper; Promotions/Low Prices; Premium Pricing and Market Positioning; Price Point Accessibility; Price Competitiveness; Economic Value and Positioning Strategy	Foti *et al.* (2019), Eldesouky *et al.* (2020), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Narassima *et al.* (2025), Balcıoğlu *et al.* (2025), Czine *et al.* (2025), Wallmo and Kosaka (2025), D'Adamo *et al.* (2024)
Value communication and economic benefits	Price Level/Premium; Value Proposition Communication; Price/Cost Proposition	Nath and Agrawal (2023), Li (2025), Mitrache *et al.* (2025), Zhang *et al.* (2025)

Source(s): Authors' own elaboration

Table 6. Services, warranties and convenience attributes

Second order attribute	First order attributes	Source papers
Customer service and technical support	After-Sales Service and Maintenance Support; Technical Support Services	Nath and Agrawal (2023), Zhang *et al.* (2025), D'Adamo *et al.* (2024)
Distribution networks and product availability	Product Availability and Distribution Accessibility; Delivery Quality (speed, condition, reliability, arrival time)	Nath and Agrawal (2023), Li (2025), Chaloupkova *et al.* (2025), Zhang *et al.* (2025)
Usage convenience and user experience	Ease of Integration/Use Convenience; Digital Features for User Convenience; User Experience Design	Nath and Agrawal (2023), Wurster *et al.* (2020), Balcıoğlu *et al.* (2025)

Source(s): Authors' own elaboration

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Table 7. Design, aesthetic, form and sensory symbolism attributes

Second order attribute	First order attributes	Source papers
Sensory experience and tactility	Sensory Properties (texture, shape, colour); Sensory/Tactile Design	D'Adamo *et al.* (2024), Indrawati *et al.* (2025)
Symbolic design and cultural meaning	Symbolic Design Cues	Zhang and Chen (2025)
Visual design elements and aesthetics	Peel Colour Tone Saturation (Deep Orange); Playful and Aesthetic Design; Visual Design Appeal and Aesthetic Integration	Lambarraa-Lehnhardt *et al.* (2021), Tsai *et al.* (2012), Mitrache *et al.* (2025), Zhang *et al.* (2025), Balcıoğlu *et al.* (2025)

Source(s): Authors' own elaboration

perceived value by linking the product to environmental and personal health benefits (Seo *et al.*, 2016). Additionally, consumer acceptance improves when sustainable choices are seamlessly integrated into everyday routines, suggesting that practical ease of adoption significantly influences consumer behaviour toward sustainable products (Nath and Agrawal, 2023). In the reviewed studies, five sustainability-cue groups emerge: circularity, environmental metrics, material choices, production integrity, and certification. Table 1 summarises the attributes within each group.

3.1.2 Eco-labels, packaging, and certifications. Consumers rely on eco-labels as trusted markers of environmental responsibility and product quality, positively influencing their purchasing decisions (Eldesouky *et al.*, 2020). Additionally, sustainable packaging contributes to consumer perceptions by visibly demonstrating environmental commitment and enhancing perceived product value (Seo *et al.*, 2016). The reviewed studies identify six groups of labelling and packaging attributes, covering: how eco-information is displayed and made accessible on pack; how claims are verified and made trustworthy; whether labelling follows recognised standards; how visual elements such as colour and icons aid quick comprehension; what the packaging material itself is made of; and how the physical design and size of packaging reinforces or undermines the sustainability message. Table 2 details the specific attributes within each group.

3.1.3 Country of origin and local ecosystem. Products carrying strong local identities — such as Protected Designation of Origin labels — are often preferred for their authenticity and support of local economies (Lambarraa-Lehnhardt *et al.*, 2021). Additionally, biodiversity-friendly production practices can positively influence consumer preferences by signalling ecological stewardship (Foti *et al.*, 2019). Table 3 indicates that origin-related attributes operate through two closely linked mechanisms: geographic identity and local production systems. These attributes matter because they connect sustainability claims to place-based authenticity, local economic support, and perceived ecological stewardship.

3.1.4 Quality (functional attributes). Sustainable products face a notable perception challenge: to gain adoption, they must match or exceed the functional performance of traditional alternatives, because consumers treat quality as a threshold condition rather than a dimension, they will trade off for sustainability (Nath and Agrawal, 2023). This challenge further extends into contexts where eco-labelled goods influence purchase decisions through perceived quality enhancements linked to environmental and health attributes (Eldesouky *et al.*, 2020). Four groups of functional quality attributes are identified: overall performance and reliability; physical composition and intrinsic properties; safety and structural durability; and sensory qualities such as taste, texture, and freshness. Together these show that consumers assess functional quality across multiple dimensions, not simply whether a product "works". Table 4 details the specific attributes within each group.

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3.1.5 Price. While some consumers pay a premium for sustainability features, broader market penetration is constrained by price sensitivity, which can override environmental concerns for cost-sensitive segments (Eldesouky *et al.*, 2020; Kato *et al.*, 2023). Strategies to attract price-sensitive consumers might include not only setting competitive prices but also highlighting the long-term cost savings associated with purchasing sustainable products, such as lower energy costs or reduced waste (e.g. Eldesouky *et al.*, 2020). As shown in Table 5, price-related attributes in the literature extend beyond simple cost levels to include market positioning and the communication of long-term economic benefits. This pattern shows that consumers evaluate sustainable products through both immediate affordability and perceived long-term value. Pricing is therefore not external to design strategy; it shapes whether sustainability is interpreted as accessible value or as an unjustified premium.

3.1.6 Service including warranty and after-sales. Robust after-sales services and warranties are essential for consumer trust in sustainable products, and their absence is a notable barrier to adoption, as consumers fear potential maintenance and support issues (Nath and Agrawal, 2023). Three groups of service attributes are identified: after-sales support and warranties that reduce consumer risk; distribution and availability that determine whether sustainable options are practically accessible; and ease of use that supports integration into everyday routines. Table 6 details the specific attributes within each group.

3.1.7 Design, aesthetic, form and sensory symbolism. Visual design elements often act as powerful, non-verbal cues for quality; for example, the colour saturation of a fruit peel can signal ripeness (Lambarraa-Lehnhardt *et al.*, 2021), while the overall aesthetic form and visual appeal of a product and its packaging can significantly influence choice (Foti *et al.*, 2019; Mitrache *et al.*, 2025; Seo *et al.*, 2016). In identity-relevant categories such as sustainable luxury fashion, the "Aesthetic Style/Fashionability" is a prerequisite for adoption, often taking precedence over sustainability credentials (Nath and Agrawal, 2023), with "Aesthetic Design Excellence" being used to justify a premium market position (D'Adamo *et al.*, 2024). The tactile and ergonomic qualities are also critical, as sensory design features like material finish enhance the user experience and can create a premium feel (Yuan *et al.*, 2022). Finally, design has a powerful symbolic dimension, using "Symbolic Eco-Signalling Design Cues" like leaf motifs to appeal to a consumer's environmental identity (Kato *et al.*, 2023), or incorporating cultural and heritage motifs to create a deeper, more resonant brand story (Kato *et al.*, 2023; Zhang and Chen, 2025). Table 7 summarises the design, aesthetic, and symbolic attributes associated with consumer perceptions of sustainable products.

3.1.8 Attribute distribution across product contexts. The content analysis shows clear patterns in how attributes are used across product and market contexts, with some clusters receiving sustained attention and others largely overlooked. Cross-category studies on green consumer products cover the widest range of attributes but tend to emphasise generic levers — circularity, production processes, information display — rather than context-specific features. In Agri-Food and Beverages, the emphasis shifts strongly towards production methods, certification, origin, and price, supported by on-pack information and packaging materials. In Fashion, Textiles and Luxury Accessories, sustainability is more often framed through transparency, value communication, and basic service assurances, with less systematic attention to packaging or end-of-life design. Technology-intensive categories such as Green Household Appliances and Mobility/Automotive place more weight on performance, durability, and price, reflecting the higher perceived risk of these purchases, while studies on Sustainable Packaging concentrate almost exclusively on information and labelling, largely ignoring service and use-phase dimensions.

Across all contexts (Figure 3), a consistent hierarchy emerges. On the sustainability side, Production Process Integrity and Methods stands out as the most frequently examined attribute, alongside environmental metrics, material choices, and formal certifications. On the informational side, Information Display and Communication Systems is especially prominent, followed by sustainable packaging materials and labelling standards. Geographic origin, functional quality, and pricing strategy also rank highly, confirming that consumers assess

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	A1: Sustainability Cues					A2: Information Transparency Features (Eco-labels, Packaging, and Certifications)						A3: Country of Origin and Local Ecosystem		A4: Quality (Functional Attributes)				A5: Price and Economic Attributes		A6: Services, warranty, aftersales, Convenience in availability			A7: Design, Aesthetic, Form & Sensory Symbolism		
	Circularity & End-of-Life Management	Environmental Impact Assessment & Metrics	Material Selection & Resource Efficiency	Production Process Integrity & Methods	Sustainability Certification & Standards	Information Display & Communication Systems	Information Transparency & Verification	Labelling Standards & Compliance	Packaging Design Elements & Aesthetics	Sustainability of Packaging Materials	Visual Communication & Graphic Design	Geographic Origin & Regional Identity	Local Production Systems & Manufacturing	Performance Quality & Effectiveness	Physical Properties & Composition	Safety Durability & Structural Integrity	Sensory Quality & Experience	Pricing Strategy & Market Positioning	Value Communication & Economic Benefits	Customer Service & Technical Support	Distribution Networks & Product Availability	Usage Convenience & User Experience	Sensory Experience & Tactility	Symbolic Design & Cultural Meaning	Visual Design Elements & Aesthetics
Agri-Food & Beverages		3	2	8	7	5		3	2	4	3	7	3	1	3	1	2	6			1				1
Cross-Category / General Green Consumer Products	4	1	1	3	1	2				3		1	2	3	1	1		2	1		1	1	1		2
Fashion, Textiles & Luxury Accessories	1	1	1	1			2	1				1		1		2		1	1	2	1	1	1		
Green Household Appliances & Home Energy Technologies							1							1					1	1	1				1
Mobility & Automotive (NEVs & Sustainable Transport)		1	2	1		1								4					1			1		1	1
Sustainable Packaging						2			1																
All Products	**5**	**6**	**6**	**13**	**8**	**10**	**3**	**4**	**3**	**7**	**3**	**9**	**5**	**10**	**4**	**4**	**2**	**9**	**4**	**3**	**4**	**3**	**2**	**1**	**5**

Figure 3. Product/Market context vs product attributes categories. Source: Authors' own elaboration

sustainable products through a combined lens of provenance, performance, and price. By contrast, sensory experience, service and support, availability and convenience, and especially aesthetic style and symbolic design cues receive far less attention, even in categories where they are likely to matter most — fashion, premium food.

These patterns reflect a concentration of scholarly attention rather than direct evidence of their substantive market importance, and are partly explained by the fact that technical and informational attributes are more readily standardised and tested than service-related, sensory, and symbolic dimensions. The resulting skew points to a clear opportunity: future research should give more systematic attention to services, use experience, and meaning-laden design as drivers of sustainable product adoption, and should extend the attribute framework to two notably absent contexts — green buildings and product–service systems — that are well developed in the broader sustainability literature but largely absent from consumer-perception studies of SPD.

3.2 Consumer value dimensions for SPD

Building on the analysis of product attributes, it is essential to explore how consumers interpret those attributes through underlying value dimensions. While attributes such as quality, eco-labels, and price are crucial in shaping purchase decisions, their influence depends on the values consumers assign to them (ElHaffar *et al.*, 2020). These consumer values encompass the benefits sought throughout the product lifecycle, from pre-purchase considerations to post-purchase experiences (Sheth *et al.*, 1991; Sweeney and Soutar, 2001). Given the previously discussed attitude-behaviour gap — where pro-environmental attitudes do not always translate into sustainable purchasing (Sivapalan *et al.*, 2021) — understanding these values is critical. By aligning sustainable product attributes with the six value dimensions consumers bring to purchase decisions, businesses can more effectively address the gap between positive attitudes and actual behaviours (Biswas and Roy, 2015; Lai, 1995; Sivapalan *et al.*, 2021). Table 8 summarises the six value dimensions identified in the reviewed studies and the main benefits consumers associate with each. These cover: whether a product performs well and offers good value for money (functional); whether it is genuinely better for the environment (green); how it makes the consumer feel (emotional); how it affects their standing with others (social); how well they understand what they are buying (epistemic); and whether it is practically available

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Table 8. Consumer value dimensions in relation to SPD

Value category	Key contents	Source papers
Functional value	Core performance, reliability and quality (performance utility, "genuine/fresh/less-treated", safe formulation); economic and cost utility (price fairness, durability, savings, cost-per-use, transaction utility); health and safety utility; service and risk reduction (warranty, after-sales support); functional assurance bundled with eco-attributes (energy efficiency, low operating cost, safe resource use, origin/quality reassurance)	Dihr *et al.* (2021), Waris *et al.* (2021), Yuan *et al.* (2022), Nath and Agrawal (2023), Lambarraa-Lehnhardt *et al.* (2021), Essiz and Senyuz (2024), Borin *et al.* (2011), Bovea and Vidal (2004), Foti *et al.* (2019), Wurster *et al.* (2020), Eldesouky *et al.* (2020), Koszewska *et al.* (2020), Li (2025), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Narassima *et al.* (2025), Vaikma *et al.* (2025), Mitrache *et al.* (2025), Zhang *et al.* (2025), Villanueva *et al.* (2025), Edenbrandt *et al.* (2025), Balcıoğlu *et al.* (2025), Xu *et al.* (2025), Zhang and Chen (2025), Wallmo and Kosaka (2025), Aggarwal *et al.* (2024), Shaikh *et al.* (2024), D'Adamo *et al.* (2024)
Green value	Environmental impact reduction and eco-benefits (lower footprint, waste, resource use; biodiversity and climate protection); altruistic and biospheric concern; trust in eco-labels/ certification; animal welfare and humane treatment; circularity and recyclability; green consumption values and nature relatedness	Waris *et al.* (2021), Li *et al.* (2021), Yuan *et al.* (2022), Kumar and Basu (2023), Forleo *et al.* (2023), Lambarraa-Lehnhardt *et al.* (2021), Essiz and Senyuz (2024), Borin *et al.* (2011), Tsai *et al.* (2012), Bovea and Vidal (2004), Bossle *et al.* (2015), Seo *et al.* (2016), Foti *et al.* (2019), Wurster *et al.* (2020), Eldesouky *et al.* (2020), Koszewska *et al.* (2020), Li (2025), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Huang *et al.* (2024), Narassima *et al.* (2025), Vaikma *et al.* (2025), Zhang *et al.* (2025), Villanueva *et al.* (2025), Edenbrandt *et al.* (2025), Balcıoğlu *et al.* (2025), Xu *et al.* (2025), Zhang and Chen (2025), Indrawati *et al.* (2025), Wijayatunga *et al.* (2024), Wallmo and Kosaka (2025), Aggarwal *et al.* (2024), Shaikh *et al.* (2024), D'Adamo *et al.* (2024)
Emotional value	Warm-glow and moral satisfaction ("doing the right thing", reduced guilt); reduced anxiety and greater confidence/assurance; pride, joy, and ethical gratification (status from responsible choices; pride in region or brand); hedonic enjoyment and aesthetics (taste, sensory pleasure, design beauty, minimalism); affective attitudes toward eco-products and futures (children, future generations)	Yuan *et al.* (2022), Kato *et al.* (2023), Essiz and Senyuz (2024), Borin *et al.* (2011), Tsai *et al.* (2012), Bovea and Vidal (2004), Eldesouky *et al.* (2020), Li (2025), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Narassima *et al.* (2025), Vaikma *et al.* (2025), Mitrache *et al.* (2025), Zhang *et al.* (2025), Villanueva *et al.* (2025), Balcıoğlu *et al.* (2025), Xu *et al.* (2025), Zhang and Chen (2025), Indrawati *et al.* (2025), Aggarwal *et al.* (2024), D'Adamo *et al.* (2024)

(*continued*)

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Table 8. Continued

Value category	Key contents	Source papers
Social value	Social norms and approval (descriptive and injunctive norms, marketplace fairness); status and signalling (eco-self, prestige/heritage, responsible parenting, circular/eco-luxury image); community and local support (supporting local farmers, regions, rural development); identity and belonging (regional pride, green self-identity, community/influencer signalling); moral and fairness concerns toward others (workers, producers, society)	Waris *et al.* (2021), Yuan *et al.* (2022), Kumar and Basu (2023), Lambarraa-Lehnhardt *et al.* (2021), Essiz and Senyuz (2024), Tsai *et al.* (2012), Bovea and Vidal (2004), Bossle *et al.* (2015), Foti *et al.* (2019), Wurster *et al.* (2020), Eldesouky *et al.* (2020), Koszewska *et al.* (2020), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Narassima *et al.* (2025), Vaikma *et al.* (2025), Balcıoğlu *et al.* (2025), Xu *et al.* (2025), Zhang and Chen (2025), D'Adamo *et al.* (2024)
Epistemic value	Knowledge gain and learning (understanding labels, footprints, biodiversity, production methods, technology); information sufficiency, transparency and verifiability (blockchain, detailed panels, carbon data, clear eco-attributes); curiosity and novelty (innovative materials/tech, circular solutions, configurators); confidence from knowing enough to choose correctly and update mental models	Waris *et al.* (2021), Yuan *et al.* (2022), Lambarraa-Lehnhardt *et al.* (2021), Essiz and Senyuz (2024), Bossle *et al.* (2015), Foti *et al.* (2019), Wurster *et al.* (2020), Li (2025), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Zhang *et al.* (2025), Villanueva *et al.* (2025), Edenbrandt *et al.* (2025), Balcıoğlu *et al.* (2025), Xu *et al.* (2025), Wallmo and Kosaka (2025), D'Adamo *et al.* (2024)
Conditional value	Context- and situation-dependent utility: category or risk context (food vs. non-food, high-risk categories); segment- or occasion-specific amplifiers (EV owners, gifting, special editions, promotions, policy incentives, high petrol prices); availability and convenience in specific situations; price and budget constraints as situational filters; religion or norms as enabling/blocking conditions; opt-out or "no choice" when greener substitutes are available	Waris *et al.* (2021), Nath and Agrawal (2023), Kumar and Basu (2023), Essiz and Senyuz (2024), Wurster *et al.* (2020), Eldesouky *et al.* (2020), Paffarini *et al.* (2025), Chaloupkova *et al.* (2025), Balcıoğlu *et al.* (2025), Czine *et al.* (2025), Wallmo and Kosaka (2025), D'Adamo *et al.* (2024)

Source(s): Authors' own elaboration

and affordable in their specific situation (conditional). These dimensions underpin the framework developed in Section 3.4. The following subsections detail each in turn.

3.2.1 Green value. Green value encompasses the consumer's valuation of products based on their environmental benefits, with consumers increasingly willing to pay a premium for a reduced carbon footprint or sustainable sourcing (Bovea and Vidal, 2004). Environmental consciousness and ethical motivations shape these perceptions and, in turn, satisfaction and loyalty toward green products (Bolsunovskaya *et al.*, 2023).

3.2.2 Functional value. Functional value pertains to the intrinsic utility of a product — its quality, reliability, and performance (Yuan *et al.*, 2022). For sustainable products, functional value often intertwines with durability and efficiency, aligning short-term performance expectations with long-term sustainability goals (Essiz and Senyuz, 2024).

3.2.3 Social value. Social value reflects the benefits consumers derive from products in social settings, including enhanced social image and peer approval (Essiz and Senyuz, 2024). For sustainable products, this value drives green behaviour through peer influence and social norms, but its effect varies sharply across cultural and social groups.

3.2.4 Emotional value. Emotional value is associated with the feelings and psychological satisfaction a consumer derives from purchasing or using a product (Bossle *et al.*, 2015; Essiz

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and Senyuz, 2024). In SPD, it can be amplified by aligning product attributes with personal identities — for example, pride in making environmentally responsible choices — strengthening the consumer–product relationship (Essiz and Senyuz, 2024).

3.2.5 Conditional value. Conditional value depends on the specific circumstances in which the product is used or purchased (Bolsunovskaya *et al.*, 2023). In SPD, situational factors such as product availability, promotional incentives, and environmental-crisis contexts can significantly shift consumer choices (Essiz and Senyuz, 2024).

3.2.6 Epistemic value. Epistemic value involves the arousal of curiosity, provision of novelty, and the satisfaction of knowledge-seeking behaviour related to a product (Bolsunovskaya *et al.*, 2023; Essiz and Senyuz, 2024; Yuan *et al.*, 2022). Sustainable products often fulfil this value by offering innovative features and new technologies that are environmentally friendly (Essiz and Senyuz, 2024).

3.2.7 Category-specific value hierarchies. A critical finding from this analysis is that no universal value hierarchy applies across sustainable products — the relative importance of the six dimensions shifts dramatically by product category. Figure 4 provides a synthesised overview of how each value type varies across the key product categories represented in the research, assessed by the strength and frequency of drivers identified in the data.

Functional value emerges as a non-negotiable prerequisite rather than a dimension consumers are willing to trade off. In Consumer Durables, performance shortfalls trigger strong negative reactions regardless of environmental credentials; sustainability considerations only become relevant once functional adequacy is secured. A similar pattern holds in Mobility and Automotive, where range, reliability, and cost form hard adoption thresholds that green benefits cannot override, even though context-dependent factors such as policy incentives and fuel prices can relax or tighten those thresholds. Agri-Food and Beverages departs from this sequence: here, environmental and functional concerns — organic certification, production methods, safety, taste — act as joint primary drivers. Because many food attributes are credence in nature, claims such as "pesticide-free" simultaneously signal environmental impact and personal health, making green and functional value effectively inseparable. Novel technologies and circular products face the most demanding configuration: they must prove functional viability while overcoming distrust and perceived risk, and simultaneously deliver convincing environmental benefits, with conditional value often decisive — religious compliance, situational availability, and promotional timing can make otherwise attractive solutions either adoptable or untenable. As products move further away

Product Category	Green Value	Functional Value	Emotional Value	Social Value	Epistemic Value	Conditional Value
Food & Beverage *(Organic beef, tuna, olive oil, produce)*	Primary Driver	Primary Driver	Key Influencer	Minor Factor	Key Influencer	Key Influencer
Consumer Durables *(Appliances, tires, home energy tech)*	Key Influencer	Prerequisite & Primary Driver	Key Influencer	Minor Factor	Baseline	Key Influencer
Automotive (NEVs) *(Electric vehicles, sustainable transport)*	Primary Driver	Prerequisite & Primary Driver	Key Influencer	Primary Driver	Key Influencer	Primary Driver
Fashion & Luxury *(Sustainable fashion, leather, apparel)*	Key Influencer	Primary Driver	Primary Driver	Key Influencer	Key Influencer	Key Influencer
Novel Tech / Circular Products *(3D meat, green toys, circular diapers, packaging)*	Primary Driver	Key Influencer	Key Influencer	Key Influencer	Primary Driver	Primary Driver

Figure 4. Context-dependency matrix of sustainable value drivers. Source: Authors' own elaboration

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from familiar consumption patterns, more value dimensions must meet minimum thresholds simultaneously, substantially raising the design bar.

Social value closely tracks product visibility and identity relevance — central in high-visibility categories such as Mobility and Automotive and Fashion, where status signalling and identity expression are key, but largely peripheral in low-visibility domains such as Consumer Durables and privately consumed food. Green value plays two distinct roles: in Novel Technologies and explicitly green product lines, environmental performance is the core value proposition without which the product has little reason to exist; in established categories such as Fashion or Consumer Durables, sustainability operates as a secondary differentiator or premium justification once functional and aesthetic expectations have been met. Emotional value — feelings of pride, moral satisfaction, or reduced guilt — appears consistently as a meaningful amplifier rather than a stand-alone driver, strengthening decisions already justified on functional or environmental grounds rather than compensating for weaknesses in those domains. Conditional value functions less as an additional benefit and more as a contextual gatekeeper, determining when otherwise attractive sustainable options are practically viable for specific segments and situations. Taken together, these patterns suggest that emotional and social benefits are best treated as reinforcing layers built on a solid functional and green foundation, rather than as substitutes for it.

3.3 Data-driven insights for measuring consumer perception

This section examines the quantitative methods used in the 39 reviewed studies. Tables 9 and 10 offer a comprehensive overview of the empirical techniques used. Specifically, Table 9 details the assessment methods for consumer perceptions of sustainable product attributes, summarising data collection techniques, analytical tools, and the independent and dependent variables considered. Meanwhile, Table 10 outlines the approaches for evaluating consumer values, presenting similar methodological details. Across both tables, there is a methodological concentration around structured surveys, choice experiments, and variance-based modelling. While these approaches are valuable for estimating stated preferences, they privilege pre-specified, cognitively accessible attributes and capture less effectively the tacit, embodied, relational, and post-purchase dimensions of sustainable product use. As a result, the current evidence base is stronger on what consumers can report in standardised settings than on how sustainability is experienced in routine practice, which helps explain the weaker coverage of service, sensory, and symbolic design dimensions in the SPD literature.

3.4 Integrated framework for consumer-based SPD

In response to the research gaps identified and insights gained from the SLR, this section proposes a six-stage framework for customer-based SPD (Figure 5). Drawing on established theories and methodologies, it systematically maps the interconnections between design dimensions, consumer values, and product attributes. The framework moves from value identification through perceived benefits, attribute selection, preference ranking, and design-dimension mapping to customer valuation modelling and iterative refinement.

3.4.1 Identifying and categorising consumer values. The framework begins by identifying and categorising consumer values into six key dimensions — functional, social, emotional, epistemic, conditional, and green — drawing on consumption value theory and its extensions in sustainable consumption research (Sheth *et al.*, 1991; Sweeney and Soutar, 2001; Sivapalan *et al.*, 2021; Essiz and Senyuz, 2024). Because quantitative surveys tend to overlook nuanced or context-specific perspectives, this step is strengthened by integrating qualitative exploratory methods — such as in-depth interviews or ethnographic studies — with traditional survey-based approaches. Such mixed-method designs allow researchers to surface consumer values that standardised instruments may not fully reveal.

3.4.2 Identifying perceived benefits. The second stage identifies the benefits consumers associate with each value dimension. The theoretical foundation for this connection draws on

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Table 9. Assessment methods of consumer perception towards attributes

Attribute	Data collection	Analytical method	Independent variables	Dependent variables	References
Sustainability cues	Online survey; Lab-based experiment; Choice-based conjoint experiment	ANOVA; Logistic regression; Hierarchical Bayes estimation	Sustainability, compromise, and confidence attributes	Consumer attitudes toward circular economy; Preferences in transportation scenarios; User preferences in electric vehicle features; Most/least desirable attributes in purchase context	Koszewska *et al.* (2020), Wurster *et al.* (2020)
Country of origin and local ecosystem	Online survey; Face-to-face interviews	Binary logistic regression; Choice Experiment (CE); Conditional logit; Cluster analysis; Social Network Analysis (SNA)	Frequency of canned tuna consumption; Consumer preferences for meat attributes; Motivations leading to agri-food product choice	Significance of attributes; Consumer choices; Consumer profiles and indirect relationships	Eldesouky *et al.* (2020), Forleo *et al.* (2023), Foti *et al.* (2019)
Quality (functional attributes) and service including warranty and after-sales	Self-administered survey	PLS-SEM	Functional and service-related attributes of sustainable products	Purchase Intentions	Nath and Agrawal (2023)
Price	Online survey; CE	Conditional logit; Cluster analysis	Country of origin, production method, labels, and price (beef attributes); Consumer beliefs, attitudes, and environmental concerns	Consumer preferences; Consumer segmentation	Eldesouky *et al.* (2020)
Eco-labels, packaging and certifications	Online survey with quota sampling; Structured questionnaire; Face-to-face interviews	Chi-square test; Cronbach's alpha; One-way ANOVA; SEM; PLS; Factor analysis; Principal component analysis	Presence/absence of labels; Consumer attitudes toward environmental certification; Environmental message levels; Knowledge of eco-labels	Consumer attraction to product; Perception of safety and environmental impact; Purchase intention for green and energy-efficient products; Consumer choice of environmentally friendly food products	Dihr *et al.* (2021), Eldesouky *et al.* (2020), Kato *et al.* (2023), Koszewska *et al.* (2020), Lambarraa-Lehnhardt *et al.* (2021), Waris *et al.* (2021)
Design	Online survey; Web-scraping; Multiple surveys and questionnaires	MCDA; K-means clustering; Ordinal regression; KeyBERT; Word2Vec; Kano model	Product aesthetics; Appearance design; Visual appeal; Demographic factors; Design preferences	Purchase intentions; Consumer satisfaction; Willingness to pay; Customer experience ratings; Aesthetic evaluation indicators	D'Adamo *et al.* (2024), Mitrache *et al.* (2025), Zhang *et al.* (2025)

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Table 10. Consumer value assessment methods

Value	Data collection	Analytical method	Independent variables	Dependent variables	References
Conditional value	Structured online survey	PLS-SEM; ANN; IPMA	Conditional Value; GAR; CES	Purchase Intentions	Essiz and Senyuz (2024)
Emotional value	Structured online survey; Questionnaire	PLS-SEM; ANN; IPMA; Simple Regression; SEM; CFA	Emotional Value; GAR; CES; Firm Environmental Strategy; Customer Environmental Consciousness; Consumption Values	Purchase Intentions; Green Product Development	Essiz and Senyuz (2024), Tsai *et al.* (2012), Yuan *et al.* (2022)
epistemic value	Structured online survey; Questionnaire	Exploratory Factor Analysis; PLS-SEM; ANN; IPMA; SEM; CFA	Epistemic Value; GAR; CES; Firm Environmental Strategy; Customer Environmental Consciousness; Consumption Values	Purchase Intentions; Structure of Values and Attitudes	Bossle *et al.* (2015), Essiz and Senyuz (2024), Yuan *et al.* (2022)
Functional value	Structured online survey; Questionnaire	PLS-SEM; ANN; IPMA; SEM; CFA; Simple Regression	Functional Value; GAR; CES; Firm Environmental Strategy; Customer Environmental Consciousness; Consumption Values	Purchase Intentions; Structure of Values and Attitudes; Green Product Development	Essiz and Senyuz (2024), Tsai *et al.* (2012), Yuan *et al.* (2022)
Green value	Structured online survey; Questionnaire	PLS-SEM; ANN; IPMA; SEM; CFA; Simple Regression	Green Value; GAR; CES; Willingness to Pay (WTP); Customer Environmental Consciousness; Consumption Values	Average Variance Extracted (AVE); Declared vs. Revealed WTP; Purchase Intentions	Bovea and Vidal (2004), Essiz and Senyuz (2024), Li *et al.* (2021), Yuan *et al.* (2022)
Social value	Face-to-face interviews; Structured online survey; Questionnaire	Exploratory Factor Analysis; PLS-SEM; ANN; IPMA; SEM; CFA; Simple Regression	Social Value; GAR; CES; Firm Environmental Strategy; Customer Environmental Consciousness; Consumption Values	Demand-Side Analysis for Sustainable Products; Green Product Development; Purchase Intentions	Bossle *et al.* (2015), Essiz and Senyuz (2024), Tsai *et al.* (2012), Yuan *et al.* (2022)

Source(s): Authors' own elaboration

Means-End Chain (MEC) theory, which proposes that consumers link product attributes to consequences and, ultimately, to personal values through a chain of associations guiding purchase decisions (Reynolds and Gutman, 1988). In the context of green consumption, Sivapalan *et al.* (2021) illustrate how value categories mediate the relationship between product attributes and perceived benefits. Since traditional methods of eliciting perceived benefits rely on self-reported data prone to social desirability bias, this stage is strengthened by experimental designs — such as discrete choice experiments — and real-world behavioural analyses, which validate whether the benefits consumers claim to value in principle also drive their actual purchasing behaviour.

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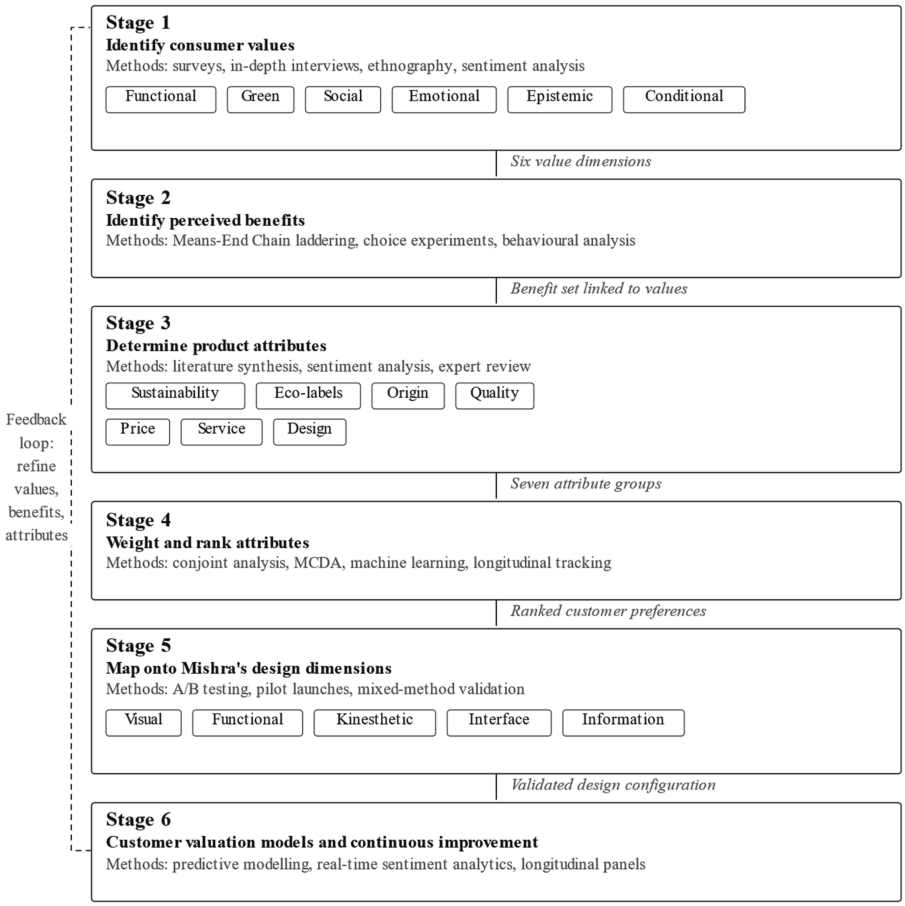

Figure 5. Data-driven framework for customer-based SPD. Source: Authors' own elaboration. **Note(s):** Six sequential stages move from identifying consumer values, through perceived benefits and product attributes, to attribute weighting, design-dimension mapping, and customer valuation modelling. Each stage names the key methods drawn from the SLR. Bordered chips indicate the substantive content of each stage: six consumer value dimensions (Stage 1), seven product attribute groups (Stage 3), and Mishra's (2016) five design perception dimensions (Stage 5). The dashed line on the left indicates that valuation results iterate back to refine values, benefits, and attributes through continuous improvement

3.4.3 Determining product attributes. Drawing on the identified consumer values and perceived benefits, the framework specifies which product attributes warrant emphasis in the design. A key risk at this stage is concentrating on a pre-specified attribute set and overlooking emerging consumer concerns. Integrating sentiment analysis from social media and digital platforms mitigates this risk by capturing real-time consumer feedback and surfacing attributes that structured survey instruments may not have initially considered, ensuring that the attribute portfolio remains aligned with evolving consumer preferences.

3.4.4 Evaluating the weight of attributes and preference ranking. Once the relevant product attributes have been identified, the framework determines their relative importance and preference ranking (Horsky and Rao, 1984). Advanced analytical techniques — conjoint analysis and Multi-criteria Decision Analysis (Soota, 2014) — are employed to quantify the influence of each attribute on consumer decision-making. These approaches can be further

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enhanced by machine learning algorithms, which enable the processing of large datasets and more accurate predictions of consumer preferences while accommodating ongoing data streams rather than relying on static, one-time assessments.

3.4.5 Mapping attributes against consumer preferences. With attribute weights established, this stage validates whether the prioritised attributes genuinely resonate with consumer behaviour beyond stated intentions. Quasi-experimental designs and real-world interventions — such as pilot launches or A/B testing — reduce the biases inherent in hypothetical choice scenarios and provide a behavioural reality check before full-scale design commitments are made. Building on these validation strategies, the framework incorporates Mishra's (2016) model of design perception to structure how validated attributes are translated into design decisions. The model identifies five dimensions of the product experience: the visual dimension covers aesthetic appeal and initial attraction; functional addresses utilitarian performance and reliability; kinaesthetic focuses on ergonomic and tactile qualities; interface encompasses ease of interaction, particularly salient for technologically complex products; and information concerns the clarity and accessibility of product-related details.

3.4.6 Customer valuation models and continuous improvement. The final stage develops customer valuation models using predictive modelling and machine learning algorithms to quantify the value consumers assign to specific product attributes, thereby informing pricing strategies, marketing communications, and product development priorities (Ahmad *et al.*, 2018; Codini *et al.*, 2020; Hanley *et al.*, 2008). To ensure that these models do not become static as consumer preferences evolve, the framework integrates continuous feedback loops using real-time analytics and sentiment analysis. Longitudinal tracking complements this real-time capability by revealing how the weight of specific attributes shifts as consumers gain direct experience with the product — enabling the design process to remain adaptive rather than anchored to a single moment of data collection.

4. Discussion and conclusion

This review set out to clarify how sustainable product attributes and consumer value dimensions are conceptualised and distributed across the SPD literature, and to use those insights to develop an integrated, data-driven framework for customer-based SPD. The findings advance prior reviews in a consequential direction. Where earlier syntheses — notably Camilleri *et al.* (2023) and Marcon *et al.* (2022) — catalogued green product attributes and consumer responses to them, the present analysis reveals that the relationship between attributes and consumer values is neither straightforward nor universal: the same attribute can function as a primary purchase driver in one product category and be effectively irrelevant in another. This context-dependency is compounded by a methodological pattern in the literature — the dominance of structured surveys and choice experiments — that systematically privileges technical and informational attributes while leaving tacit, experiential, and post-purchase dimensions largely unmeasured. Understanding what this means for SPD theory and practice, and how the proposed framework addresses it, is the focus of the sections that follow.

4.1 Theoretical and practical contributions

Two theoretical constructs are sharpened by the findings. First, the attitude–behaviour gap is refined in an important way: its magnitude is not fixed but varies systematically with product category and with the nature of the environmental attributes involved. Where attributes are performance-based, as in consumer durables, the gap is wide because functional shortfalls disqualify a product before sustainability credentials are even considered. Where attributes are credence-based, as in agri-food, environmental and functional concerns fuse rather than compete, and the gap narrows accordingly. This category-dependence has been noted in the broader consumer behaviour literature but has not previously been integrated into SPD frameworks in a way that connects it directly to design decisions. Second, the review extends

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consumption-value theory by demonstrating that value dimensions do not operate as additive contributors to purchase decisions but as context-dependent filters, with different dimensions assuming gatekeeping or amplifying roles depending on the product category. Functional value functions as a prerequisite in durables and automotive contexts; social value becomes central where product use is publicly visible; emotional value consistently amplifies decisions already justified on functional or environmental grounds rather than substituting for them. These refinements jointly open empirical questions — taken up in Section 4.2 — about how value hierarchies stabilise or shift as consumers gain direct experience with sustainable products across different cultural and regulatory settings.

The proposed framework complements, rather than displaces, established SPD toolkits. Where Life Cycle Assessment provides rigorous environmental accounting, it offers limited purchase on dynamic consumer preferences; the proposed framework acts as a practical front-end to LCA and to models such as Design for Sustainable Behaviour and Circular Design (Ceschin and Gaziulusoy, 2016), unifying dispersed tools under a single, value-centric process with a real-time feedback capability that static traditional assessments lack.

For practitioners, the six framework stages compress into three, summarised in Figure 6. Diagnosis identifies which values dominate the focal category — establishing, for instance, whether functional and green value operate as joint drivers or whether one gates access to the other before sustainability is considered at all. Prioritisation then quantifies trade-offs between candidate sustainability features, concentrating R&D investment on the attributes that carry the greatest combined environmental and consumer value. Validation moves beyond stated preferences to revealed choices, testing whether prioritised attributes genuinely drive behaviour rather than simply attracting positive survey responses. The pay-off of this sequence is that sustainability enters the product as a component of the core value proposition rather than as an added-on credential. When sustainable features are designed to deliver on the values consumers already hold — reliability, cost savings, or sensory quality, depending on the category — sustainability becomes part of the quality promise rather than a separate, potentially compromising feature. This directly reduces the cognitive and motivational conflict that underpins the attitude–behaviour gap.

The framework equally offers policymakers a route beyond purely informational interventions — labels, awareness campaigns — toward targeted measures grounded in category-specific consumer drivers. Diagnosing the value hierarchy of a given category reveals whether a subsidy, infrastructure investment, or regulatory instrument is most likely to shift behaviour, and where each is likely to fail. The EU's Right to Repair directive illustrates

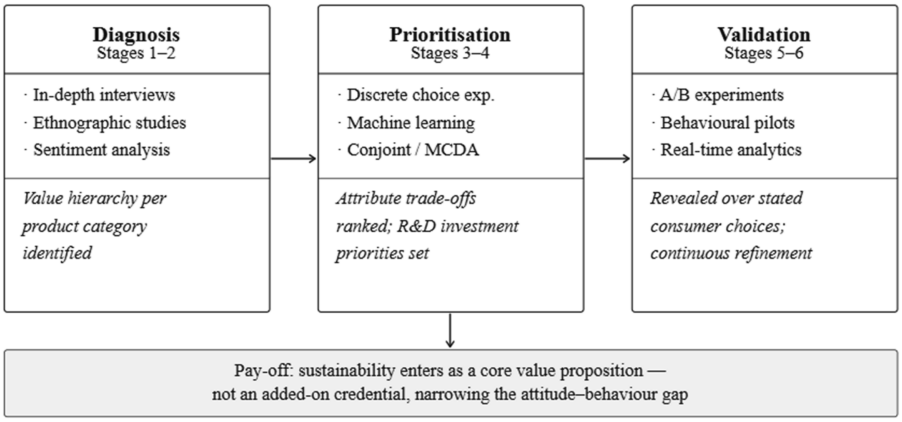

Figure 6. Three-stage practitioner sequence for customer-based SPD. Source: Authors' own elaboration

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this alignment potential: firms that design repair services to deliver on consumer values of reliability and long-term cost savings, rather than merely meeting the directive's minimum requirements, convert a compliance obligation into a source of loyalty and repeat purchase. The bottom-up market validation that the framework provides complements top-down regulation by revealing which sustainable features consumers will actually adopt and sustain in use.

4.2 Limitations and directions for future research

Several limitations of the present study warrant acknowledgement and point to productive directions for future inquiry. First, the framework integrates consumer values with Mishra's (2016) design perception dimensions while treating sustainability as a separate element, which may restrict its capacity to capture the inherently holistic nature of SPD. Integrating LCA techniques directly within Mishra's dimensions — rather than alongside them — would yield a more unified analytical structure in which consumer perceptions and environmental impacts are evaluated through a common lens.

Second, the cross-sectional nature of the evidence base constrains the framework's capacity to track preference shifts driven by emerging societal norms, technological change, or evolving environmental awareness. Longitudinal study designs and real-time data collection — incorporating continuous sentiment analysis and panel methodologies — would substantially enhance the framework's adaptability to dynamic market conditions.

Third, the framework remains to be validated empirically across industries, cultures, and regulatory contexts. Value hierarchies and attribute preferences are known to vary with cultural setting, as do the norms, infrastructural conditions, and regulatory environments that moderate the attitude–behaviour gap. The theoretical proposition that the gap's magnitude depends systematically on whether environmental attributes are credence-based or performance-based similarly awaits direct empirical examination. Cross-industry case studies, experimental designs, and structured industry partnerships are therefore needed to establish the framework's external validity and practical scope.

Fourth, important limitations characterise the corpus this review synthesises. The concentration of extant research on technical and informational attributes, at the expense of experiential and relational dimensions, partly reflects the methodological conventions that dominate the field. Beyond these thematic gaps, two substantive domains that figure prominently in the broader sustainable design literature — green building design and product–service systems — are effectively absent from the consumer-perception studies synthesised here, a lacuna the present review necessarily inherits. The restriction of the search to Scopus and to English-language peer-reviewed sources compounds this absence. Extending coverage to Web of Science, Google Scholar, and grey literature would bring built-environment and PSS-based research into view; extending the attribute framework itself to these domains, alongside methodologies suited to capturing experiential and symbolic design dimensions, represents a clear priority for future synthesis.

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