

## Article

# Designing Sustainability Today: An Analytical Framework for a Design for Sustainability Model in European Fashion and Furniture Industries

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**Abstract:** The proposed article addresses pressing sustainability challenges, advocating for a profound transformation of existing development models, particularly emphasizing sustainable production and lifestyles. Utilizing a research method grounded in a comprehensive international knowledge base, the study explores the evolution of design for sustainability (DfS) approaches. Its significant contribution lies in systematically investigating connections among diverse DfS approaches, providing an initial framework for situating practices within the fashion and furniture industries. The research outcomes obtained iteratively involve mapping design-driven sustainability practices in European fashion and furniture companies. This mapping reveals a transition from a product-centric to an organization-centered design perspective, calling for a holistic ecosystemic framework to revolutionize business operations. The article analyzes contemporary design-driven practices, proposing an interpretative model that identifies ongoing practices fostering incremental changes toward sustainability guided by design. Furthermore, the article outlines a three-stage design-driven sustainability continuum, synthesizing potential future trajectories. Beyond contributing to the understanding of current practices, the research provides insights into future possibilities, highlighting the transformative role of design in reshaping consumeristic systems. Ultimately, the study offers valuable insights into the transformative power of design, paving the way for sustainable business practices in the fashion and furniture industries.

**Keywords:** design for sustainability; design-driven innovation; sustainable innovation; sustainable value creation; industry transformation



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## 1. Introduction

Addressing the challenges of sustainability and their related complexities by design is a radical shift of perspective for the design itself and requires a change in its epistemological foundations. Since its formal development as a practice and then as a codified discipline, it has followed the cycles of transformation from pre-industrial systems to mass manufacturing and globalized economies. Looking back to its early stage of development, the design embedded a solid implicit and sometimes even explicit political manifesto in the beginning. It was part of that Western paternalistic vision willing to extend to all mass-produced goods those functional, perceptive, and aesthetic qualities lost during the shift from craft-manufactured products to standardized ones responding to the rigid constraints of the first industrial revolution paradigm [1,2]. The foreseen creation of a distributed, accessible, and democratized market of quality products and services was suddenly overcome by the acceleration of technological, economic, and societal transformations throughout the following development phases, where several interlinked phenomena have reversed the original political intents. Indeed, while the Western world was progressively embracing advanced and “soft-industrial sectors” and service economies, the continuous growth of

productivity and technological development did not reduce the expansion of manufacturing industries. They were only re-engineered on more efficient models, delocalizing the most impactful phases to developing countries and creating the premises for a system where over-production and over-consumption phenomena are now accompanied by increasing inequalities in the geographical distribution of wealth and accessibility to goods and services. Within this scenario, design has been losing its original political afflatus by playing a crucial role in eliciting consumerism, embracing a simplistic “innovation-driven” perspective fueled by consumers’ cultural attitude to “newism” [3]. The benefits of sophisticated user-centered innovation approaches to smaller consumer niches were often not linked to any considerations or awareness of the impacts of design choices within larger social, cultural, and environmental ecosystems. Therefore, to concretely address sustainability issues, it is essential to acknowledge that design was part of the driving forces that created the problem and its complexities [4]. In response, an increasing number of critical voices have emerged within the design community since the last decade of the 20th century, and a general call to action is currently crossing the whole system of design practitioners and scientists.

Suppose the “human-centric approach” of design was its distinctive contribution during the early stages of industrial development to increase products and service qualities and accessibility. In that case, the current challenges need a larger and different approach. As the complexity and interwoven nature of sustainability issues require a systemic approach, design also needs to reframe its approaches and methodologies by broadening its domain of intervention from sub-systems related to specific design problems to a larger eco-systemic dimension. The “design for sustainability” domain of practice and research does emerge with this purpose by embracing, in its most advanced expressions, a “more-than-human approach”. It acknowledges a multiple and holistic vision, decentralizing its anthropocentric focus by giving legitimacy to human and non-human entities and their related agencies [5]. This means assigning to design the role of leading complex multi-stakeholder and multi-disciplinary actions to support the transition towards an environmentally sustainable, socially equitable, and culturally inclusive paradigm.

In light of this perspective, a quick transformation of the current manufacturing system and related distribution and consumption dynamics is critical to addressing contemporary challenges in sustainability and, at the same time, a privileged context to observe and experiment with design actions and interventions. Design practices have an already established role within this context, especially in those industries related to daily use products, such as fashion and furniture, acknowledged for their “design content” and for having been at the very center of the explosion of globalization and mass consumption dynamics. They are considered among the most impactful industries in terms of environmental pollution and usage of non-renewable resources and their contribution to social and cultural degradation [6]. Indeed, their extensive delocalization models had impoverished local production systems in their countries of origin; on the other hand, they exploited new social communities and environmental resources in their new manufacturing locations [7]. Therefore, promoting new design strategies within these industries could represent a critical step towards sustainable transition. This will also contribute to reshaping manufacturing models within advanced economies towards circular eco-systemic models, bringing back their essential social and cultural values and reducing their environmental impacts. Furniture and fashion are not, in fact, only “industrial products” but they also belong to the so-called “culture-intensive industries”, which include a system of tangible and intangible artifacts that defines the relationships between individuals and their social and cultural environment and contributes to the creation of a universe of values and daily practices of collective interactions [8,9]. That is to say, they are also “cultural products” implicitly recognized as bearers of deep layering of meanings and narratives, becoming tools of mediation between individuals and their social environment, and real “identity prostheses” contributing to defining subjective and collective identities [10,11]. Within this particular category of products, design acts as a tool of resignification, capable of codifying indicated

meanings and reconfiguring them into new narratives [9]. These goods' peculiar "cultural nature" and strict relationship with people's identities and lifestyles bring a second level of potential positive impact in transforming these specific industries. They can become active agents of systemic change by also positively affecting consumers' behaviors, engaging them in the needed shift from a "consumption" attitude to a "caring" one [3].

Considering the above, this study establishes a foundation for future research and practical applications in sustainable development within specific domains. The authors introduce a three-level design-oriented framework to guide academic researchers and industrial designers. They contribute to the discussion by presenting representative cases from the fashion and furniture industries. They illustrate how design solutions can go beyond economic profits to maximize social, cultural, and environmental benefits. The following main tasks were carried out to achieve the purpose: A comprehensive literature review was conducted on design for sustainability (DfS) and an analysis of relevant cases was completed to identify emerging trajectories for further investigation and theoretical modeling of future DfS strategies. Section 2 of this paper conducts a literature review to establish the theoretical foundation for the inquiry into design for sustainability, elucidating its relevance to the furniture and fashion industries. The literature delves into the concept of evolution and the modeling of new production practices, providing a framework that aligns with the paper's findings. These insights underpin the development and discussion of the interpretative model presented. Section 3 details the methods and materials, outlining the process of mapping sustainable practices among European fashion and furniture companies. The section thoroughly justifies the qualitative research approach, elucidating data collection and analysis methods and sources. This information enhances the study's replicability, enabling researchers to employ the same design, compare findings, and uphold the fundamental aspect of replicability in academic research. Section 4 unveils the results and discusses contemporary sustainable practices shaped by design in fashion and furniture. The initial research's knowledge is organized, emphasizing critical aspects like modeling current circular production behaviors and addressing challenges in transitioning to a sustainable model through design-led practices. The interpretative model identifies three primary design domains: product-centric, organization-centric, and organization ecosystem-centric domains, ultimately pinpointing design directions for fostering innovative perspectives in fashion and furniture. Section 5 concludes by explaining how the presented model opens avenues for understanding how organizations can strategically adopt circular solutions through design, fostering meaningful change. Section 6 outlines limitations and future perspectives, emphasizing the practical significance and suggesting the policy implications derived from the analysis.

## 2. Literature Review

A preliminary examination of the existing literature was carried out to establish the theoretical underpinning of the study. The aim was to clarify the concepts associated with design for sustainability (DfS) to understand the framework through which an organization generates, captures, delivers, and distributes value within a sustainable system via innovations in product design or business processes, drawing upon design theories and practices for their development or execution. This process sought to devise a model suitable for analyzing the study's outcomes and crafting propositions for the research model. Data from various sources, including Scopus, Science Direct, and Google Scholar, were collected to ensure comprehensive topic coverage. These sources comprised scientific articles, papers, conference proceedings, and book chapters. The study covered a time horizon of more than 20 years (1994–2023) to examine the comprehensive evolution of the topic [12]. Identifying keywords posed challenges due to the interdisciplinary nature of the issues, with a focus on business, management, and engineering. Initially, six keywords were used to research the documents: design, sustainability, eco-design, evolution, principles, and innovation, which led to the identification of 1681 documents.

From a first analysis of the literature, it emerged that, in recent years, the attention of scholars moved from an anthropocentric perspective towards a holistic one. Although linking sustainability elements, the previous construct needs to pay more attention to acknowledging and promoting diversity and foregrounding an ecosystemic worldview. This observation aligns with responses from international institutions and academia, as highlighted by Ceschin and Gaziulusoy [12]. Accordingly, the query line was edited to meet the broader scope of the study, introducing the concepts of futuring and a more-than-human perspective: design for sustainability AND ecodesign AND strategic AND (system\* OR ecosyst\*) AND more than human. Following this, a filtering process was employed, involving several steps to code the reference literature. Titles and abstracts were checked first to exclude publications unrelated to the study's focus. Duplicates were removed, resulting in 60 remaining publications. A complete reading was then carried out to apply inclusion and exclusion criteria, including the language of publication (English), study design (qualitative and quantitative studies), and outcomes (articles with frameworks and guidelines supporting the investigation of design-driven approaches towards sustainability). The first reading indicated a predominance of engineering, business, and management articles. The authors included only articles highly relevant to the study's purpose, coding the models illustrated to draft their framework. A second reading further refined the selection, narrowing the sample to 39 publications (Appendix A). The literature review process is summarized in Table 1.

**Table 1.** Literature review process.

The document included (typology)	Scientific articles Papers Conference proceedings Book chapters
Time horizon	2000–2023
Keywords (1st query)	Design for Sustainability AND Ecodesign AND Strategic AND (System* OR Ecosyst*) AND more than human
Search applied to titles, abstract, and keywords	Scopus → 26 references WOS → 17 references Google Scholar → 100 references
Screening of titles and abstract	60 references, excluding publications unrelated to the study
Complete text analysis and final selection	39 references, selecting only publications that support some of the practices identified further

The initial systematic review supported the study model's foundational structure. It enhanced our understanding of how design theories and practices align with modern sustainability criteria, encompassing aspects such as low toxicity, recyclability, scalability, and performance in a sustainable development model [13,14].

This study's first result was identifying an existing taxonomy about design for sustainability (DfS) proposed by Fabrizio Ceschin e Idil Gaziulusoy [1,15]. This framework explored an evolutionary perspective to explore how design has been applied to address sustainability challenges as one of the most complete studies on how various design for sustainability approaches have been developed. It overcame disciplinaries and national and sectorial barriers. According to this, the authors adopted this model as the starting point of their investigation.

Sustainability emerged as a systemic property, implying that products, services, technologies, and organizations cannot reach the sustainability goal alone. Starting from this perspective, the author adapted the identified framework to the current European manufacturing industries' state-of-the-art codifying theoretical and practical approaches in the DfS

field. Their efforts demonstrate how the adoption of sustainable development models has not thoroughly or effectively addressed changes at the systemic level but is characterized by partial perspectives ranging from a focus on sustainable materials to an integrated action on corporate sustainability that underline that they must work together as elements within larger sustainable systems [16].

Based on the discussion, the literature review aims to depict current design-driven sustainable practices within the fashion and furniture industries. Four primary paths toward sustainability implementation have emerged from this exploration, three established in academic and industrial realms and one derived from the literature. These paths include adherent sustainable technical expertise, innovative approaches to production, consumption, and organizational models, novel ecosystemic structures, and emerging disruptive scenarios. In light of these findings, this paper outlines the sustainable innovation trajectories observed in manufacturing contexts to delineate design strategies that could inspire and advance fresh perspectives in sustainable fashion and furniture design. This endeavor aims to explore potential pathways toward new contexts and infrastructures, their composition, and the requisite production methods, all aiming to foster a more sustainable manufacturing landscape.

From the operational point of view, the literature review identified three progressive macro levels in approaching sustainable practices from a DfS perspective that corresponds to what Buchanan [17] has proposed as the four orders of design, which presented the new extension of design deeper into organizational culture. This progressive evolution of the scopes and aspects that design has changed related to sustainable transition emerges at the intersection of the investigated paths and hacking models/methods proposed by other scholars.

Ceschin and Gouziusoloy [1] proposed a framework that systematically documents the predominant methods through which design has been employed to address sustainability issues from an evolutionary standpoint. This framework consolidates various approaches to design for sustainability (DfS) with a comprehensive perspective that moves from the product level to the socio-technical system level.

Baldassarre et al. [18,19] propose five suggestions for academic researchers, industrial designers, and business managers seeking to utilize their professional influence to contribute actively to the shift toward sustainable development.

Fletcher's work [20] summarizes the design for sustainability strategies applied to the fashion sector and proposes a direction to use them operatively.

Aakko and Koskennurmi-Sivonen [21] synthesize the components of sustainability and fashion design. Their model is designed to assist fashion designers interested in incorporating sustainability. The analysis and model address which principles and practices should be considered in the context of sustainable fashion design.

Chang et al. [22] explored how to bridge the divide between the development of sustainable products and the product's lifecycle by enhancing the disassembly process at each stage of the product lifecycle.

Waage's framework [23] facilitates product development teams to comprehensively understand the significant sustainability challenges and opportunities within a product category during the initial development stages. The intention is also to facilitate effective communication among top management, stakeholders, and product developers.

Waage [24] expanded upon existing frameworks that aim to comprehend the interrelations among different assessment principles, strategies, actions, and tools concerning industrial ecology, human and labor rights, and corporate social responsibility. It proposes a "road map" intended for adoption by product designers and product development managers. The framework presents a four-phase process for incorporating systems and sustainability perspectives into product design, manufacturing, and delivery decisions.

Byggeth et al. [25] incorporated both social and ecological dimensions of sustainability into product development from a strategic business standpoint. The approach utilizes backcasting from fundamental sustainability principles. It adopts a strategic perspective

and incorporates a modular system of guiding questions derived by examining these principles and the product lifecycle.

Manzini et al. [26] outlined the sustainability potential of product service systems (PSS) within the context of emerging stakeholder relationships and partnerships, which lead to a convergence of economic interests and potential systemic optimization of resources.

Maxwell and van der Vorst [27] proposed a method to offer practical advice to businesses and industries to develop sustainable products and services. It aims to seamlessly integrate this methodology into existing corporate strategies for cleaner production and product development systems.

This hacking process relies on data triangulation involving collection, categorization, and coding. The diverse models/methods are categorized similarly, following the recommendation of Corbin and Strauss [28], while considering the study's focus on application sectors—furniture and fashion—and the design-driven perspective. Additionally, this choice aligns with an effort to address the gaps identified in the literature and models related to a broad investigation of design application areas, spanning various realms from the micro (product) [1,18–21,23] to the macro (spaces and systems) [1,24], and adopting a significantly business-centric perspective [17,22,26,29,30]. This results in modeling three levels of DfS: product-centric [31–39], organization-centric [40–48], and organization ecosystemic-centric [49–55]. They provide a theoretical guide to map selected cases and a knowledge basis for creating the proposed DfS interpretive model for manufacturing industries.

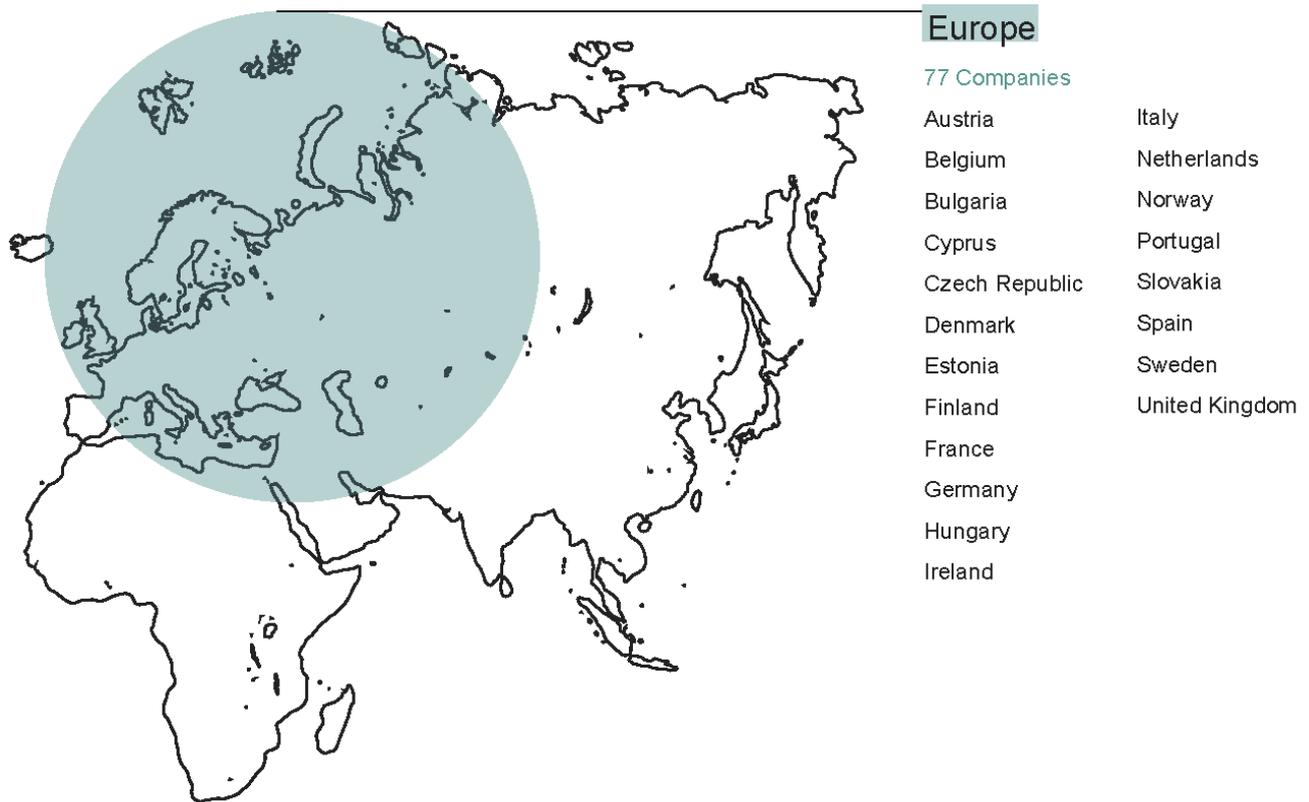
### 3. Materials and Methods

The processed data are collected from the knowledge reservoir generated by the ECODeCK Project team at the Design Department of Politecnico di Milano. Specifically, the information is obtained from the authors' involvement in the MICS Project, an Extended Partnership between universities, research centers, and enterprises funded by the Ministry of University and Research through funds made available by the European Union under the NextGenerationEU program, as well as the results of one of the author's doctoral research project [56].

The research methodology involved an initial desk research phase followed by a case study methodology, chosen for its appropriateness in dealing with complex analyses of existing knowledge on the investigated topic [57]. This approach allows the transformation of individual cases into functional units that can be explored in their original context, considering multiple variables and qualities. Bridging the gap between quantitative and qualitative methods, the case study methodology supports the authors in inductive theory generation [57].

DfS is still a relatively young discipline [1], so the case study methodology provides practical knowledge that supports interpretations through case studies [58]. Methodologically, the research adopted a four-stage approach to generate novel insights, drawing upon the theoretical guidance and knowledge foundation outlined in the theoretical framework derived from the literature review. The first phase focused on mapping European manufacturing companies, focusing on the fashion and furniture sectors, and collecting their sustainability-related production practices. The initial desk research and literature review covered ten years from 2012 to 2022, and it was chosen based on the European Commission's development initiatives. In 2012, the EU Commission established a framework for setting ecodesign requirements for energy-related products, drafting the initial ecodesign legislation (see Ecodesign Directive 2009/125/EC).

Approximately 90 companies across 20 European countries demonstrating mature levels of sustainable performance have been identified [31] (Figure 1).



**Figure 1.** Map of the companies' locations.

These companies exhibit a diverse composition, encompassing furniture, fashion, and textiles companies actively working to enhance sustainability throughout their production of products and processes. Their efforts extend beyond the design phase, encompassing management and technological aspects. Consistent with industrial development trends on the continent, most of these companies are classified as micro- or small-and-medium-sized enterprises (SMEs) [59,60]. Out of the 90 companies mapped, 77 European initiatives—44 from the fashion and 33 from the furniture sectors—were selected as case studies to be further investigated. The presented cases have distinguished themselves by how they implement DfS practices within their systems. These companies are adopting a design-driven approach to support their transition toward sustainability, engaging and involving their ecosystems. Such approaches consider (1) a design-engineering perspective covering punctual solutions of preferring sustainable materials, redesigning their products and processes, and adopting a product lifecycle vision. (2) A strategic approach that focuses on transforming the organizations through a passage from manufacturing a product to providing a service, to a change in their business models—often towards circularity—towards the performance of a concerted effort to operate in ways that enhance rather than degrade society and the environment. (3) An ecosystemic design that moves from recognizing the complexity of productive systems and the richness of actors involved to collaborating towards a proactive engagement of actors as peers towards the establishment of a sustainable ecosystem.

They are characterized by a sustainable vocation, often applied through circular initiatives, that stands as a sustainable alternative to the generation of previous practices. These new approaches minimize the input of resources into the system and the loss of waste, emissions, and energy output to mitigate adverse effects without compromising growth and prosperity (Appendices B and C).

The subsequent inquiry phase involved qualitative work, complemented by specific information from a second round of in-depth desk and field research that engaged the

researcher in sectorial events (Salone del Mobile 2023, Milano Unica 2023, and MFW SS24). The desk research and mapping phase occurred from March 2023 to October 2023.

The collected resources were analyzed through content analysis [59] to identify recurring patterns and establish associations between various DfS practices. We defined units of meaning, quantifying the frequency of individual words and phrases based on predefined categories for coding: sustainable practices, sustainable materials, fashion design, and product design. During the analysis phase, we began to outline the framework of our taxonomy of current circular practices within the fashion supply chain. We identified three primary steps in the supply chain where circular practices were most frequently implemented: raw materials supply, product manufacturing, and waste collection and management. This subsequent research phase enabled us to refine the model further and pinpoint specific design-driven sustainable fashion and product design approaches currently employed within the fashion and furniture supply chain.

All the cases examined demonstrated a robust commitment to proactively addressing the evolving needs of the surrounding environment, as evidenced by their sustainability efforts. The outcomes of this additional phase facilitated the identification of current DfS practices in the sustainability fashion and furniture fields. The delineation of these directions represents an initial effort to comprehend how a shift toward sustainable design is achievable by incorporating specific design-driven aspects.

Furthermore, the gathered data has been analyzed using the strategy for sustainable products proposed by the European Commission, aimed at bolstering the continent's internal market. This additional step allowed the authors to blend an academic approach with an industry-oriented perspective. Specifically, the EC strategy seeks to expedite change, foster a competitive environment to achieve higher sustainability standards and serve as a platform for shared learning from collective insights and exemplary practices. This approach was deemed pertinent to identifying factors influencing innovations in design for sustainability (DfS). Moreover, the strategy reflects the maturity of the sustainability trajectory through extensive consultation with a diverse array of stakeholders, including participating companies. Additionally, the three pivotal areas of progress outlined in the strategy correspond with those explored in the study. As discussed by numerous scholars, these areas are instrumental in nurturing progressive, transformative stages towards sustainability: firstly, the conformance phase, which emphasizes compliance with regulations and certifications; secondly, the reformative phase, which entails comprehending the entire product lifecycle to enhance operational efficiency, reduce costs, and mitigate environmental impacts through supply chain monitoring and obtaining certified sustainability contributions; and thirdly, the transformative phase, which focuses on formulating and executing innovation policies.

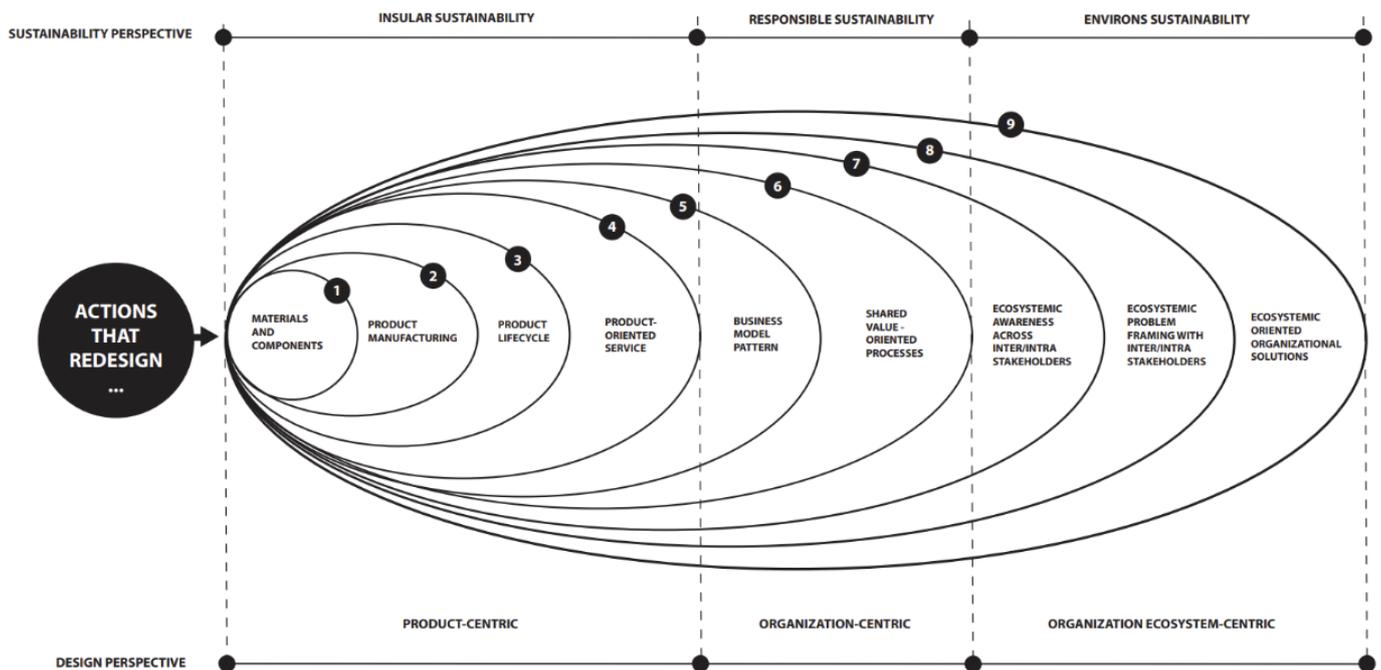
## 4. Results and Discussion

### 4.1. *Introducing the Model*

Building upon the previous parts, this paper seeks to conceptualize present-day sustainable practices driven by design within the fashion and furniture industries. Here, the findings from the literature review are presented and so is the applied methodology, providing insights into how qualitative implementations operate along the three defined design areas:

- Product-centric;
- Organization-centric;
- Organization ecosystem-centric.

The proposed model represents the original contribution of this work (Figure 2).



**Figure 2.** The DfS interpretative model for fashion and furniture industries (authors' original elaboration).

The bottom line defines the design perspectives in adopting DfS solutions, and the upper line provides the way such solutions consider and impact the sustainability fundamental dimensions, namely the environment, economy, society, and culture [60,61]. For the upper line, the research identified three dimensions that move progressively concerning horizontal advancement, illustrating how the different design perspectives embed the sustainability dimensions incrementally:

- **Insular sustainability:** from a technical focus to an incremental view of innovation towards innovations in which sustainability is seen as a single pillar, often the environmental one, that must be addressed [1].
- **Responsible sustainability:** a progression from a mono-focal perspective to a plural vision that generally engages sustainability practices in resolving internal matters within a company to a concentration on instigating alterations in broader socio-economic systems that extend to the company's immediate stakeholders beyond its limits [1,62–66].
- **Environs sustainability:** this is a holistic perspective that considers sustainability from innovations that address the system issues towards a focus on making changes on broader eco-socio-economic systems, beyond the firm's immediate stakeholders and boundaries but recognizing and involving all the factors that contribute to the ecosystem [1,67,68].

The bottom line delineates the evolutionary perspective of design for sustainability (DfS) that intervenes in specific aspects to (re)design sustainable solutions.

Product-centric design provides the baseline for approaching DfS from an insular and ecological point of view. According to [69]'s analysis, the 1980s were primarily driven by ethical considerations. Still, the 1990s were more concerned with scientific and technological solutions to sustainability-related issues, such as design for the environment (DfE), green design, and eco-design. Even if the terms for the first two methods are still interchangeable, eco-design emphasizes the entire lifecycle of a product, from the extraction of raw materials to its eventual disposal [70,71]. In 2016, Ceschin and Gaziulusoy proposed the most comprehensive and accepted definition—in academia—to frame these two dimensions. Green design “encompasses design interventions aimed at incrementally improving products through the development of new materials, the replacement of materials, and (more

generally) the improvement of a product's individual qualities" [12] (p. 120). Eco-design focuses on "improving existing products or developing new products by considering the entire product lifecycle, from material extraction to disposal improving" [12] (p. 121).

From these definitions, we can understand the relationship between the two areas and that eco-design contains the concepts of green design, which have evolved along a progressive path toward sustainability from a technical perspective. The technical vocation from these dimensions addresses how designers juggle many, often conflicting, constraints to balance aesthetics, manufacturability, and functional goals within a sustainable product specification. Designers must leverage technical problem-solving skills and be open to external information at all stages of the design cycle [72].

For these reasons, being product-centric is the first level of progressive evolution from a design perspective. This embeds the ability to manage the design activity through the whole product development process, from the conceptual phase to the material selection, mechanical engineering and manufacturing studies, and product documentation. Coherently, this dimension embraces, progressively, four primary areas of action, namely the following:

- Materials and components addresses how, in the design concept, components and material selection act concurrently when grafting sustainability at an early stage of product development [73,74].
- Product manufacturing involved promoting product innovation and efficiency to address environmental problems [75].
- Product lifecycle(s) encompasses a substantial amount of design-related information, providing insights into various stages of the product's existence, resource utilization, and potential environmental consequences [76].
- Product-service system(s) transfers the business focus from developing and selling physical products only to offering products and services that re-orient production and consumption models [77].

At this phase, design is involved in sustainable development at an operative level, and it mainly deals with tangible artifacts (product-centric) addressing one specific sustainable environmental dimension.

The organizational-centric approach refers to the creation of an innovation strategy that reorients current unsustainable trends in production and consumption practices and supports companies to shift their focus from merely designing (and selling) only physical products to designing (and selling) a system of products and service systems (PSS) that are collectively capable of meeting specific customer demands [78]. In this context, the design enables a competitive advantage and market impact through strategies that envision long-term strategic and systemic projects that often require substantial organizational commitments and investments [79,80]. From a sustainability perspective, this area embraces the context of innovation strategy and management through innovation methodology that uses design principles, practices, approaches, and tools to transform the manufacturing system towards sustainability progressively.

Starting with the PSS initiative applies a strategic design approach for sustainability, an integrated system of goods, services, and communications consistent with sustainability from a medium- to long-term perspective while also being economically and socially viable. Creating sustainable business models implies a new set of stakeholder interactions and/or collaborations, new economic interest convergences, and corresponding optimization of systemic resources. Design is a strategic process for designing and implementing sustainable business models [17,81,82]. The transformation engages designers as actors to link human needs and aspirations with fresh opportunities and ideas from science, technology, and business in developing and promoting sustainable business models that enable strategy-led sustainability [83].

In this scenario, companies can positively impact (new) stakeholders, enabled by PSS, regarding value-creation strategies. These strategies are based on four principles [84]: firstly, contributing to the ecological system by effectively managing the utilization of natural

resources; secondly, employing environmentally friendly materials; thirdly, operating within an efficient ecosystem; and fourthly, fulfilling societal needs globally and locally. Design acts within the framework of CSR that creates actions that can lead to opportunities for growth and cost reduction for companies or even a competitive advantage. What characterizes this area is the further evolution of strategic design that pushes companies to act beyond their internal compartments, considering their actions, impacts, and effects on the system where they operate, and design contributes as a resource for society and territories at large [85].

Coherently, this dimension gradually embraces two main areas of action, namely the following:

- The business model pattern integrates sustainability into the core business and value creation process (i.e., business strategy, business model, and the value-generating processes and products) [86,87].
- Shared-value-oriented processes combine sustainability at the macro level with the economic, social, and environmental dimensions [88].

At this phase, design is involved in sustainable development at the organizational level, and it participates in the strategic decision-making process inside the organization. The impact of design practices is closely linked to corporate sustainable development approaches and implementations, which are starting to include sustainability's social and cultural dimensions.

The organizational ecosystem-centric approach refers to holistically transforming the context of action. In the realm of technology and innovation management, the notion of the system and ecosystem is becoming increasingly important. According to Tsujimoto et al. [89], utilizing this fundamental idea, we define the ecosystem's goal around managing technology and innovation. Such a vision considers the informal, non-commercial, non-physical, and hidden interactions described in the actors' network relationship descriptions. As a result, ecosystems are defined by "the alignment structure of the multilateral set of partners that need to interact for a focal value proposition to materialize" ([90], p. 40; see also [91–93]), which makes ecosystems distinctive [94]. This means that the organizational ecosystem-centric dimension's primary goal is to promote a paradigm shift of such a structure by presenting new paths of actions that could have a double effect [69]: (1) promoting a change in resource allocation that improves manufacturing processes through continuous material transformation, and (2) encouraging new connections between disciplines that raise people's wellbeing in general.

Since each participant in an ecosystem pursues their objectives and demands collective decision-making by all parties, the design of the alignment structure is essential [95]. By fostering and promoting such a horizontal discourse among all relevant parties, the design enables "problem framing" strategies to facilitate alternative intentions and bring different perspectives into conversations and relationship creation, from which further innovations cascade. Then, design proposes new viable and sustainable solutions by providing tools, resources, standards, or frameworks to solve complex situations collectively.

Coherently, this dimension develops three main areas of action, namely:

- Ecosystemic awareness across inter/intra stakeholders corresponds to acknowledging sustainability, which is not a continuation of the status quo but a continuous process of co-evolution with a changing environment and actors [96].
- Ecosystemic problem framing with inter/intra stakeholders addresses the collaboration efforts between the acknowledged different actors, balancing their non-equilibrium perspectives to reach a common framework to work together [97].
- Ecosystemic-oriented organizational solutions refer to the engagement of different actors to support the transition to sustainability by organizing networks of unique initiatives connected by local, national, and international networks, fostering new ecosystems of sustainable systems [98].

At this phase, design is involved in sustainable development at an ecosystem level, and it goes beyond the corporate boundary to foster a systemic transition of the stakeholder network. The impact of design practices is related to the entire supply chain and its sectors, addressing the corporation's responsibility in activating a larger scale of sustainable transition. It focuses on a systemic dimension of sustainability, putting all the social, cultural, economic, and natural dimensions at the core.

From the study, there emerged a last dimension that we refer to as more-than-human design. This grey area refers to envisioning future design methods/approaches that are more sustainable and less predictable in an environment driven by uncertainty, climate crisis, and new socio-cultural paradigms. This theoretical category lives in the speculative dimension. It aims to provide a values-based and sustainability-focused alternative to current manufacturing industry trends by reflecting on the limitations of current scenarios [69]. A culturally sustainable perspective enables a more profound, long-lasting, and systemic transformation in line with people's attitudes, social norms, and worldviews [99,100]. This is why, drawing on Fry [101,102], we argue that a futuring approach to future thinking should consider the interlacement between technical and cultural aspects in a design-driven industry. Sustainability "is not an endpoint or a steady state: it is a process, a goal that we seek but which is always receding and is as much a matter of values and cultural reorientation" [103] (p. 8). Beliefs, behavioral patterns, and worldviews must be considered to promote a radical transformation in the current flawed systems [98]. Furthermore, activating such a transformation efficiently must engage more-than-human actors as agential and communicative beings to be at the core of a holistic-sustainability future [104].

#### *4.2. Product-Centric Design: Advancing Products to Preserve the Insular Sustainability*

The product-centric design (PCD) category represents a pivotal approach to fostering the development of sustainable products; at this level, sustainability is addressed from a single dimension, often the environmental one. At its core, this dimension has eco-design as a methodology that prioritizes ecological considerations throughout the product development lifecycle. Every stage is meticulously crafted from conception to disposal to minimize the environmental impact. Central to PCD is the emphasis on the technical aspects of sustainable materials, product engineering, and process efficiency. This approach prompts designers to innovate, seeking environmentally friendly and economically viable alternatives. By integrating lifecycle assessments and considering the entire supply chain, PC ensures that products meet immediate consumer needs and contribute positively to the planet's long-term health.

Exemplary cases from the fashion and furniture industries of research work progressively on the sustainability of their products at different levels. From a materials and components aspect, Elvis & Kresse is an example of a fashion company that proposes alternative and sustainable materials. Since 2005, the British brand has rescued and transformed retired firehoses into new raw materials for their products. In recent years, they added more recovered materials to their abacus to grow their range of responsible bags, belts, and wallets. In the furniture sector, Kartell produces the RE-CHAIR chair, created by Antonio Citterio, who experimented with the expressive capabilities of material recycling. This chair was the first ambassador of the collaboration between Kartell and the Italian Coffee company Illy. The project allowed Illy coffee capsule waste to be recycled into a new design product. By rethinking the material, Kartell works on the responsible dimension of the product.

From a product manufacturing aspect, Petit Pli is a fashion brand at the forefront of inventing and implementing innovative material technologies to address fashion challenges. The company has introduced a distinctive, patent-accepted material technology inspired by deployable satellites. In children's clothing, this translates to designing garments that can expand to seven sizes, which is equivalent to 48 months of growth. The reengineering of these products allows the maximization of the sustainable characteristics of the materials to propose a responsible solution. In the furniture sector, IKEA's research lab SPACE10

envisioned a recyclable sofa, Couch in an Envelope, weighing 10 kg, designed to fit neatly into an envelope for effortless portability. In collaboration with Panter & Tourron, the team challenges design archetypes using artificial intelligence to reimagine a couch as a lightweight, versatile, comfortable, and sustainable item. Traditionally, sofas are associated with comfort, relaxation, and a cozy atmosphere, but they often come in large, heavy, and bulky pieces in our living rooms. The Couch in an Envelope project challenges these norms by liberating furniture from its historical form, introducing a flat-packed, modular, and easily transportable concept, emphasizing a design approach that prioritizes sustainability.

From a product lifecycle perspective, Napapajiri's Circular Series revolutionizes sustainable fashion with a fully circular system achieved in just fourteen months. The cradle-to-cradle approach ensures eco-responsible products at every stage of the technical cycle. Comprising 100% recyclable models, the series employs resilient Nylon 6 and ECONYL<sup>®</sup> regenerated Nylon derived from recycled fishing nets, exemplifying a double-win for environmental conservation. This initiative signifies a significant shift towards circular fashion, prioritizing responsible production to minimize waste and contribute to a closed-loop future. The Italian furniture company Magis produced the Bell Chair in the furniture sector. This is a stackable chair designed by Konstantin Grcic, made of recycled polypropylene obtained from Magis suppliers' production waste and that of the company's regional automotive industry. The patented material almost completely excludes pure or new materials and can be 100% recycled again after use. The logistics also contribute to resource conservation. Utilizing a specially designed delivery pallet capable of transporting up to 24 chairs, the transportation effort is substantially minimized, resulting in saved CO<sub>2</sub> emissions. Additionally, the pallet serves a dual purpose as a shop display, constructed from the same recycled material as the Bell Chair. This chair design proposes an almost closed cycle concerning production and disposal processes by addressing the product's lifecycle.

As discussed, DE extends progressively beyond material choices, influencing manufacturing processes and end-of-life considerations. It encourages the adoption of circular economy principles, wherein products are designed for disassembly, reuse, or recycling. This perspective is instrumental in proactively reducing the environmental footprint of consumer goods.

#### *4.3. Organization-Centric Design: Fostering Responsible Sustainability through Organizational Change*

The organization-centric design (OCD) for sustainability is a transformative approach that propels organizations toward meaningful change. It involves deliberately integrating sustainable principles into an organization's strategy, operations, and culture. This paradigm shift goes beyond superficial changes, aiming to start a holistic transformation that aligns business objectives with environmental and social responsibility. At its heart, the organization-centric perspective requires a reassessment of values and a commitment to responsible practices. It involves identifying critical environmental and social challenges and intentionally incorporating sustainable solutions. Crucially, this approach extends beyond product or service offerings to permeate the organizational culture and changes. It involves fostering a mindset that values sustainability as a strategic advantage rather than a mere obligation. Leadership plays a pivotal role in guiding the organization toward a future where sustainability is not just a goal but an integral part of its identity.

Several companies from the fashion and furniture industries are dedicated to advancing sustainability within this dimension.

From a product-service system perspective, Uniform of the Dedicated is an innovative Swedish label that creates sustainable workwear-inspired wardrobe-essentials. They base their model on a made-to-order design and garment delivery service that enables customers to customize ready—unisex-fit tailored design—products with a logo or graphic. The process involves making selections, and the service provides a visual proposal by email, including the chosen design and application placement. This proposal can be confirmed or adjusted based on customer feedback. The listed product price includes one application

type/placement, and the final product delivery date is confirmed once the customization details are finalized. This shift towards service design sustainability aligns with evolving consumer preferences for environmentally conscious choices. It not only addresses ecological concerns, but also presents economic opportunities. The Danish startup furniture company Stykka uses innovative technology to make kitchen units more flexible, sustainable, and reusable. Crafted from birch plywood with customizable finishes, their products embrace a circular design. Its distinctive feature lies in the adaptability and sustainability it offers through services. Users can replace worn or damaged parts, and Stykka is committed to reusing or recycling these components. The brand facilitates a trade-in system, allowing users to exchange old parts for new colors. LoopKitchen is produced using a print-to-order approach via a digital manufacturing platform, minimizing overproduction and waste. The kitchen incorporates a digital twin, accessible through a QR code, offering insights into the product and aiding efficient replacements. This approach aligns with a sustainable, circular economy ethos.

From a business model transformation perspective, Ganni offers an example of how an established brand can transform its economic model to achieve sustainability. Ganni's Repeat initiative epitomizes the brand's commitment to sustainability and circular fashion through a renting model. Embracing this model, individuals gain access to a rotating wardrobe, reducing the environmental impact of fast fashion. This initiative caters to the modern desire for variety, sustainability, and a wardrobe that adapts to evolving styles without compromising eco-conscious values. Also, this forward-thinking program encourages customers to return their pre-loved Ganni pieces, fostering a closed-loop system that minimizes fashion's environmental impact. The Repeat initiative reflects a transformative shift in the fashion industry, emphasizing responsible consumption and eco-conscious practices. At the same time, in the furniture sector, the Belgian company Live Light is proposing alternatives to the business-as-usual market. Live Light ensures that furniture and accessories are reused, refurbished when necessary, and eventually recycled into new designs that align with circular design principles. Introducing a furniture subscription service not only promotes affordability but also encourages a shift towards a more sustainable consumption model. The rental furniture subscription model with month-to-month and rent-to-own options offers customers flexibility and choice. This initiative reflects a proactive approach to addressing the environmental concerns associated with the furniture industry, contributing to a more responsible and circular approach to furniture production and consumption.

From a corporate social responsibility perspective, Progetto Quid, an Italian fashion brand, represents an actor of change with a unique and inspiring mission. Founded in 2013 in Verona, it focuses on sustainable fashion and social inclusion. Progetto Quid is committed to upcycling and transforming surplus fabrics from textile companies into high-quality clothing. This minimizes waste and creates job opportunities for vulnerable individuals, including women who have faced challenges in the workforce. Progetto Quid's designs offer consumers the chance to make a positive impact through their fashion choices. Individuals choosing Progetto Quid contribute to a more sustainable and socially responsible fashion industry, proving that style and ethics coexist seamlessly. In the furniture system, Pet Lamp is a project created by designer Alvaro Catalán de Ocón that involves repurposing plastic bottles into unique and artistic lamps. The designer collaborates with local artisans worldwide to create these handmade lamps, combining traditional craftsmanship with recycled materials. Each Pet Lamp is a one-of-a-kind piece, showcasing the creativity and cultural influences of the artisans involved. The project promotes sustainable practices by repurposing plastic waste and supports local communities and traditional craftsmanship. The Pet Lamp project exemplifies social innovation by addressing environmental sustainability, community empowerment, and cultural preservation. Through its innovative approach, Pet Lamp contributes to social and ecological well-being.

As illustrated, by embracing OCD for sustainability, organizations position themselves as agents of positive change, meeting current environmental and social expectations and

actively shaping a more sustainable future. This intentional and comprehensive approach catalyzes organizational resilience, innovation, and a harmonious relationship with the broader global ecosystem.

#### *4.4. Organisation Ecosystem-Centric Design: Establishing New Frameworks for Shaping a Sustainable Paradigm*

The organization ecosystem-centric design (OECD) marks a paradigm shift in creating sustainable frameworks harmonizing with the environment, society, economy, and culture. This approach recognizes the interconnectedness of all elements within a system, emphasizing the need for holistic solutions that consider ecological, social, and economic factors. At its core, the OECD seeks to emulate the resilience and efficiency found in natural ecosystems. It entails creating frameworks where each component complements and supports the others, fostering a balanced and regenerative system. This approach transcends traditional design boundaries, encouraging interdisciplinary collaboration and diverse stakeholder engagement. Fundamental principles of OECD include a focus on circular economies at the systemic level, where resources are used efficiently and waste is minimized. Sustainable materials, renewable energy sources, and consideration of biodiversity become integral components. Furthermore, community involvement and social equity are prioritized, ensuring that the design minimizes its environmental impact and enhances the well-being of the people it serves.

Different fashion cases operate within this dimension to gradually advance towards sustainability.

From a social supply chain perspective, fibersheds represent an exciting example. A fibershed is a geographic region that defines and traces the ecological boundaries of where textiles come from. The concept emerged as a response to the textile industry's globalized and often unsustainable nature. Fibersheds aim to create a more environmentally conscious and resilient textile economy by focusing on local and regenerative practices. Farmers, ranchers, and artisans collaborate in a fibershed to produce fibers, dyes, and finished textiles within a specific region, reducing the carbon footprint associated with transportation. This holistic approach promotes transparency, ethical practices, and the revival of traditional craftsmanship. Fibersheds foster community connections, support local economies, and contribute to a more sustainable and circular fashion ecosystem by emphasizing the importance of knowing the origins and ecological impact of fashion actors and products.

From a collective problem-framing perspective, ACBC is a distinguished multi-award-winning B Corporation, leading in applied sustainability within the fashion and textile industries. ACBC acts as a catalyst for positive change, providing tangible and measurable benefits to people and the environment across various industries. Their approach is grounded in a science-based, data-driven methodology and aligns with international regulations, global frameworks, and standards. They address sustainability challenges through improved business practices by empowering brands and individuals to make more conscious decisions that benefit themselves and the planet. They collaborate closely with the brand company and stakeholders, focusing on refining processes, products, and analyses and nurturing a "mindset shift" within the ecosystem.

From a collective decision-making perspective, Son of a Taylor reshaped the system. The Danish brand is known for its commitment to providing customers with customized, high-quality T-shirts tailored to their specific measurements. The process involves customers providing their body measurements online, and then the T-shirt is crafted to fit those dimensions precisely. Son of a Taylor emphasizes sustainability in its production process, aiming to reduce waste by creating garments that are made to fit from the start. The brand aims to offer a more sustainable and customer-centric approach to clothing by focusing on personalized tailoring and using high-quality materials. In its sustainability journey, the brand realized the necessity of rethinking the system to be impactful. Establishing SON Supply, the brand's fully owned production site, is a significant step in its

sustainability journey. By having its own production site, Son of a Tailor gains greater control over the entire manufacturing process by systematizing all the different components of its supply chain and starting to create its ecosystem. This move will likely allow them to implement more sustainable practices, ensure ethical working conditions, and reduce the environmental impact. Son of a Tailor's final objective is to lead the change, which indicates a commitment to being a trailblazer in sustainable and responsible practices within the fashion industry. The brand aims to set high standards and demonstrate that operating a successful and impactful business is possible while prioritizing sustainability. Additionally, the aspiration to make change attainable for others suggests a collaborative approach, encouraging and supporting other industry players to adopt more sustainable practices. This aligns with the growing awareness and collective efforts within the fashion sector to address sustainability challenges, building new responsible ecosystems.

According to those above, by establishing new frameworks rooted in OECD, fashion companies pave the way for innovative solutions that address the complex challenges of sustainability. It is a holistic and forward-thinking approach that envisions a future where human systems seamlessly integrate with, rather than disrupt, the broader ecosystems they inhabit. While the examples gathered by the authors pertain exclusively to the fashion sector, the codified models serve as instances and suggestions that can be standardized and modified for application across various manufacturing sectors [2,105].

## 5. Conclusions

This paper examined an interpretive framework for design for sustainability (D4S) within European fashion and furniture companies, focusing on emerging design-driven sustainable practices to facilitate the adoption of sustainable solutions. The significance and breadth of design's role are increasingly acknowledged across various levels as pivotal in reshaping production, business, and systemic processes to attain sustainability objectives. Consequently, numerous companies are revamping their structures by incorporating sustainability practices to enhance their competitive edge. Through this integration, design and sustainability facilitate the introduction of new production processes, business models, and ecosystems, a topic extensively deliberated upon by various scholars [1,4,73,104,106]. In this manuscript, the emphasis is on implementing sustainable design theory within the realms of fashion and furniture practice. This proves crucial in transforming abstract ideas into tangible outcomes, positively impacting society and the environment. Prior studies have underscored the significance of addressing these challenging yet fundamental aspects. Accordingly, the author's objective is to contribute to this endeavor by establishing the groundwork for subsequent research and practical applications in this domain (see Section 6). For this purpose, we present a framework consisting of three design-oriented levels, aimed at guiding academic researchers and industrial designers seeking to participate in the shift toward sustainable development actively. The authors provide a roadmap delineating paths within three selected categories in this contribution. These represent cases showcasing transformative initiatives prioritizing social, cultural, and environmental benefits over mere economic profits through design interventions. Specifically, these cases offer nuanced insights and tangible examples of how design for sustainability (DfS) can facilitate an industrial shift towards sustainability within the fashion and furniture sectors, particularly circularity. Whether it involves upstream strategies like eco-friendly materials and designs, downstream approaches such as service-oriented models, or collaborative efforts along the supply chain, such solutions hold significant potential for fostering a circular and sustainable manufacturing industry.

## 6. Limitations and Future Scope

This study acknowledges certain limitations which the authors seek to address. Recognizing the constrained nature of the data, the paper refrains from proposing new theories but instead provides comprehensive insights aimed at understanding design-driven initiatives for promoting sustainable development. The research was conducted within the

context of the fashion and furniture industries in developed European economies, each with specific social and economic characteristics. The decision to concentrate solely on the European region was reasoned by the fact that the primary studies incorporated in this work originate from this continent. The analysis of cases revealed varying degrees of awareness and commitment to sustainability issues among different contexts, either in development or already developed. Consequently, it is essential to interpret the results within this particular framework. Across a spectrum of organizational disparities, the companies examined in this study showcased the essential traits required to amass resources, skills, and competencies conducive to advancing toward design-driven sustainability. They exhibited a commitment to closing the loop and forging new ecosystems. Integrating sustainability requisites into established practices, methodologies, and tools is imperative for cultivating a sustainable organizational culture. This internal integration should align with the company's commitment to sustainability, ensuring that components are in place to advance transformative designs, efficient processes, innovative services, business models, and network synergies. The goal is to propel the organization towards circularity, emphasizing a holistic approach to sustainability. By weaving these elements into the fabric of daily operations, the company enhances its environmental responsibility and cultivates a culture of innovation and adaptability. This strategic alignment of practices and values creates a robust framework for sustained success while contributing to a more environmentally conscious and socially responsible business ecosystem. The organization must engage in external and strategic collaborations to fortify its capabilities. This involves blending traditional practices and systems with additional know-how, competencies, and services. By seeking expertise beyond its current boundaries, the company can leverage synergies that catalyze innovation and growth. Collaborations enable the incorporation of diverse perspectives, fostering a dynamic environment that adapts to evolving industry landscapes. The infusion of external knowledge complements existing practices, enriching the organizational repertoire and enhancing its competitive edge. This strategic networking positions the company to navigate complexities with agility, ensuring a robust response to industry changes. The result is a harmonious integration of internal strengths and external resources, propelling the organization toward sustainable success in a rapidly evolving business ecosystem.

Subsequent research endeavors should delve into the factors impacting various facets of organizational design, potentially paving the way for exploring diverse research trajectories, adopting mature design-driven sustainable solutions in the fashion and furniture sectors and related barriers and opportunities [107]. Barriers include entrenched traditional practices, reluctance to deviate from established production methods, and resistance to change within industry cultures [108]. Additionally, the initial investment in technology and workforce retraining poses financial and logistical challenges [89]. However, embracing mature design-driven solutions offers the chance to respond effectively to evolving consumer demands for sustainability and innovation [109]. Efficient use of technology can optimize production processes, reducing waste and environmental impact [110]. Collaborations with designers and tech firms can bring fresh perspectives, fostering creativity and product differentiation. Moreover, as consumers increasingly prioritize sustainable and well-designed products, a growing market for companies adopting such solutions provides a competitive advantage [111]. Also, navigating these challenges and capitalizing on opportunities demands a strategic vision, collaboration across stakeholders, and a commitment to staying abreast of evolving industry trends [112]. Building a systematic classification of mechanisms and solutions with the inherent capacity to underpin the construction of new sustainable models through design. This could lead to the introduction of sustainable design-driven archetypes that could serve as conceptual frameworks, encapsulating a range of strategies and approaches that prioritize ecological, social, and economic sustainability [113]. By categorizing these design-driven solutions, the intent is to provide a structured guide for professionals seeking to integrate sustainability into their projects. These archetypes should encompass diverse elements, including materials

selection, energy efficiency, waste reduction, and community engagement. They could act as blueprints for creating environments, structures, and products that align with sustainable principles [114,115]. By adopting these archetypes, the design community can catalyze a shift towards more environmentally conscious practices, contributing to a broader transformation of how we conceive, construct, and interact with the built environment. Extending the positive experiences discussed in this study to various industries would be beneficial, creating a knowledge base applicable to diverse enterprises. Extracting universal principles from these cases could offer practical guidance for different sectors, enhancing widespread applicability and encouraging sustainable practices beyond the specific realms of the fashion and furniture industries.

In summary, design innovation and sustainability are pivotal in shaping a sustainable paradigm. This study highlights the potential implementation of design for sustainability practices, leveraging inherent business capabilities, technological expertise, and organizational strategies. It underscores the importance of considering emerging trends in evolving fashion and furniture markets, such as rental services and made-to-order production, as well as heightened consumer awareness regarding sustainability. Additionally, alongside adopting independent strategies, industry stakeholders should explore collaboration opportunities with peers and startup ventures to foster more transformative innovations.

**Author Contributions:** The paper is the result of joint research and findings. Nevertheless, Section 1 was edited by P.B., Sections 2 and 3 were edited by X.P., and Sections 4–6 were edited by E.D. The methodology presented results from research studies and projects undertaken last year by the ECODeCK team at the Design Department of Politecnico di Milano. All authors have read and agreed to the published version of the manuscript.

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## Appendix A

**Table A1.** Literature review.

Title	Type of Source	Year	Ecodesign	Strategic Design	Ecosystemic Design	More-Than-Human Design
"On the design of closed-loop networks for product life cycle management: Economic, environmental and geography considerations"	Scientific journal	2015		✓		
"Expanding participation to design with more-than-human concerns"	Conference proceedings	2020				✓
"Addressing the design-implementation gap of sustainable business models by prototyping: A tool for planning and executing small-scale pilots"	Scientific journal	2020		✓		
"The evolution of the Strategic role of Designers for Sustainable Development."	Conference proceedings	2019		✓		
"Implementing sustainable design theory in business practice: A call to action"	Scientific journal	2020		✓		
"A Systemic Design Method to Approach Future Complex Scenarios and Research Towards Sustainability—A Holistic Diagnosis Tool"	Scientific journal	2019				✓
"Business models for sustainable innovation: state-of-the-art and steps towards a research agenda"	Scientific journal	2013		✓		
"ECODESIGN: A Promising Approach to Sustainable Production and Consumption"	Book chapter	1997	✓			
"System-shifting design. An emerging practice explored"	Conference proceedings	2022			✓	
"The role of socio-technical experiments in introducing sustainable product-service system innovations"	Scientific journal	2015		✓		
"Evolution of design for sustainability: From product design to design for system innovations and transitions."	Scientific journal	2016	✓			
"More-than-human participation: Design for sustainable, intelligent city futures."	Scientific journal	2019				✓
"A strategic design approach to develop sustainable product service systems: examples taken from the 'environmentally friendly innovation' Italian prize"	Scientific journal	2003		✓		

Table A1. Cont.

Title	Type of Source	Year	Ecodesign	Strategic Design	Ecosystemic Design	More-Than-Human Design
"Product-Service Systems. Using an Existing Concept as a New Approach to Sustainability"	Scientific journal	2001		✓		
"Product-Service System applied to Distributed Renewable Energy: A classification system, 15 archetypal models, and a strategic design tool"	Scientific journal	2016		✓		
"Fashion futuring: Intertwining speculative design, foresight and material culture towards sustainable futures"	Scientific journal	2023				✓
"Rethinking Corporate Sustainability in the Era of Climate Crisis: A Strategic Design Approach"	Book	2021		✓		
"Sustainable Design: Beyond the Innovation-Driven Business Model"	Scientific journal	2011		✓		
"Shifting towards non-anthropocentrism: In dialogue with speculative design futures."	Scientific journal	2022				✓
"EcoDesign: what's happening? An overview of the subject area of EcoDesign and the papers in this special issue"	Scientific journal	2006	✓			
"Redefining success: Designing systemic, sustainable strategies"	Scientific journal	2010		✓		
"Integrating ecodesign by conducting changes in SMEs."	Scientific journal	2007	✓			
"The ecosystem blueprint: How firms shape the design of an ecosystem according to the surrounding conditions"	Scientific journal	2021			✓	
"Strategic design for sustainability: Towards a new mix of products and services"	Conference proceedings	1999		✓		
"Challenges in transforming manufacturing organizations into product-service providers."	Scientific journal	2020		✓		
"Designing for sustainability transitions of aquaculture in Finland Ecodesign and textiles."	Scientific journal	2018		✓		
"Innovation ecosystems: A critical examination."	Scientific journal	2016			✓	
"Ecodesign maturity model: a management framework to support ecodesign implementation into manufacturing companies."	Scientific journal	2013	✓			
"Sustainable Business Models through Service Design"	Scientific journal	2017		✓		



Table A2. Cont.

Country	Name of Initiative	Description of Initiative	Product-Centric				Organization-Centric		Organization Ecosystem-Centric		
			M and C <sup>1</sup>	PM <sup>2</sup>	PL <sup>3</sup>	POS <sup>4</sup>	BMP <sup>5</sup>	SVOP <sup>6</sup>	EA <sup>7</sup>	EPF <sup>8</sup>	EOOS <sup>9</sup>
Belgium	Katrien Smets	Designing t-shirts made of bio cotton and printed with organic ink.	✓								
Belgium	Atelier Noterman	'Detox Denim' collection. Using 80% less water cuts energy consumption by 80% and considerably reduces the use of toxic substances.	✓								
Bulgaria	KITNA	Accessories are made of natural materials and are hand-embroidered.	✓								
Cyprus	Hyphès Handbags	Creating upcycled handbags from reclaimed material (predominantly denim but incorporating other fabric offcuts as available).	✓								
Czech Republic	Eco-Fashion Labels	International multi-brand e-shop (and store in Prague) with a focus on sustainable, organic, fair trade, and recycled clothing.	✓								
Denmark	Son of a Tailor	Custom-made clothing is made using technology to make it available to everyone everywhere.					✓				
Denmark	Continued	A platform for circular fashion through which brands can facilitate, take back, and resell products more than once.				✓					
Estonia	Reet Aus	Dedicated to slow and ethical fashion, with an industrial upcycled collection entirely made from production leftovers.			✓						
Finland	Pumpa Upcycle	Unwanted textiles are received by Pumpa Design and are upcycled into new products.	✓								
Finland	Touchpoint	Workwear made of 100% eco-materials uses surplus materials, focusing on sustainability and lifecycle of the product and no waste.	✓								
France	Veja	Sneakers are made from organic farming and ecological agriculture materials, without chemicals or polluting processes. No advertising.						✓			





Table A2. Cont.

Country	Name of Initiative	Description of Initiative	Product-Centric				Organization-Centric		Organization Ecosystem-Centric			
			M and C <sup>1</sup>	PM <sup>2</sup>	PL <sup>3</sup>	POS <sup>4</sup>	BMP <sup>5</sup>	SVOP <sup>6</sup>	EA <sup>7</sup>	EPF <sup>8</sup>	EOOS <sup>9</sup>	
United Kingdom	Elvis & Kresse	Rescuing raw materials, transforming them into luxury lifestyle accessories, and donating 50% of profits back to charities. B-Corp certified.	✓									
United Kingdom	Insane in the Rain	Rainwear made from recycled plastic, each using material from 17–23 plastic bottles. Avoiding use of any additional, pure plastic in all industrial processes.	✓									
United Kingdom	Reclaim to Wear	The label is a pioneer in ecological fashion, being the first to collaborate with fashion houses to upcycle production off-cuts to original creations.					✓					
United Kingdom	Wool & The Gang	Yarn that is sustainable, recyclable, and biodegradable. In addition, the brand helps other companies get rid of their waste by transforming it into yarn.	✓									
United Kingdom	Christopher Raeburn	The RÆMADE ethos in particular has pioneered the reworking of surplus fabrics and garments to create distinctive and functional pieces.							✓			
United Kingdom	Finisterre	Products that are fit-for-purpose and cause as little environmental impact as possible. From materials, packaging, supply chain transparency to a supplier code of conduct. B-Corp certified.	✓									
United Kingdom	Petit Pli	Products that are designed to grow up to seven sizes using their patented technology.	✓									
United Kingdom	Riz Boardshorts	Every pair of their shorts are crafted from eco-friendly 100% recycled and recyclable fabric as well as being digitally printed in the UK using earth-friendly inks. B-Corp certified.	✓									

<sup>1</sup> M and C = materials and components; <sup>2</sup> PM = product manufacturing; <sup>3</sup> PL = product lifecycle; <sup>4</sup> POS = product-oriented service; <sup>5</sup> BMP = business model pattern; <sup>6</sup> SVOP = shared value-oriented process; <sup>7</sup> EA = ecosystemic awareness across inter/intra stakeholders; <sup>8</sup> EPF = ecosystemic problem framing with inter/intra stakeholders; <sup>9</sup> EOOS = ecosystemic-oriented organizational solutions.

## Appendix C

Table A3. Furniture sector case studies.

Country	Name of Initiative	Description of Initiative	Product-Centric			Organization-Centric			Organization Ecosystem-Centric		
			M and C <sup>1</sup>	PM <sup>2</sup>	PL <sup>3</sup>	POS <sup>4</sup>	BMP <sup>5</sup>	SVOP <sup>6</sup>	EA <sup>7</sup>	EPF <sup>8</sup>	EOOS <sup>9</sup>
Belgium	Live-Light	High-quality-design furniture for rent. Refurbished in-house to be (re)loved and (re)used.					✓				
Denmark	Stykka ApS	Modular pieces of kitchen. Digital twin to help with maintenance and repair.				✓					
Denmark	Fischer Lighting	Modular LED solutions built on existing fixtures, but offering all of the functionality, lighting quality, and energy-saving technology.					✓				
Finland	Artek	Take back the used furniture in events and exhibitions, as well as from consumers to resell.					✓				
France (Service location)	Steelcase	Not only sell products but also service to help maintain or take back when the furniture is at the end of its life.				✓					
Germany	Velda Bedding	The first 100% circular sleeping system; the product is developed according to the Cradle-to-Cradle principle (regeneration or second life possible).	✓								
Germany	Light Living	Refurbished lights.					✓				
Global	Open desk	Connect designers, consumers, and local manufacturers.					✓				
Italy	Laboratorio Linfa	Made only of reclaimed wood waterproofed with wax.				✓					
Italy	Alessandro Stabile, Martinelli Venezia for One to One	A one-piece mountable chair, produced in a single mold, and created from post-industrial recycled plastic that will help clean up the ocean.		✓							
Italy	Magis (Bell chair)	Form is designed to be comfortable. Materials come from the waste. The chair is very light and the form means it saves space when in transport.		✓							

Table A3. Cont.

Country	Name of Initiative	Description of Initiative	Product-Centric			Organization-Centric			Organization Ecosystem-Centric		
			M and C <sup>1</sup>	PM <sup>2</sup>	PL <sup>3</sup>	POS <sup>4</sup>	BMP <sup>5</sup>	SVOP <sup>6</sup>	EA <sup>7</sup>	EPF <sup>8</sup>	EOOS <sup>9</sup>
Italy	Magis (Re-Air-Chair)	Material: recycled polyolefins obtained from the recycling of poly laminates and single-use food packaging.		✓							
Italy	Magis (COSTUME)	Modular sofa. The modular system consists of a single unit, which can be interlocked in various constellations or extended with armrests.			✓						
Italy	Kartell	Chair made with recycled materials and recycled illy capsules.		✓							
Italy	Arcadia Design	Modular pieces.		✓							
Italy	Valcucine	High-quality and modular kitchen furniture.			✓						
Italy	Arper (Adell)	With a shell made from 80% recycled polypropylene, the calming form has been designed with sustainability as its foundation, putting both body and mind at ease.			✓						
Netherlands	Ineke Hans for Circuform	The first Dutch deposit chair: waste reuse, long product life, possible repair, and finally, at the end of their lifecycle, recycling into raw materials.			✓						
Netherlands	Gispen	This sofa is made out of no less than 95% recycled materials. All the materials this sofa consists of are separable; every single component can be reprocessed into a new product.			✓						
Netherlands	Gispen Ahrend	Furniture as a service (subscription renting).						✓			
Netherlands	Ahrend	Furniture as a service (subscription renting service).						✓			
Netherlands	Herso	Herso uses wood from old floors, furniture, cut offs from carpenters, and of course their own. They select good pieces of wood.			✓						

Table A3. Cont.

Country	Name of Initiative	Description of Initiative	Product-Centric			Organization-Centric			Organization Ecosystem-Centric		
			M and C <sup>1</sup>	PM <sup>2</sup>	PL <sup>3</sup>	POS <sup>4</sup>	BMP <sup>5</sup>	SVOP <sup>6</sup>	EA <sup>7</sup>	EPF <sup>8</sup>	EOOS <sup>9</sup>
Netherlands	Desko	Furniture as a service (subscription renting).					✓				
Norway	Stokke	The chair that grows with the child: easy to change according to the child's needs.		✓							
Spain	Pet Lamp	Empowering people to give plastic a second life.						✓			
Sweden	IKEA	Consumers bring their used furniture.					✓				
Sweden	Green Furniture Company	Modular furniture for public furniture.		✓							
Sweden	Form Us With Love for IKEA	Modular kitchen.		✓							
Sweeden	stolab	The product aims at reducing the amount of wood taken from the forest. They also reuse offcuts or products that become faulty during production, or reuse those that have been returned by customers to form new products.									✓
Switzerland & Sweden	Panter&Tourron & Space 10	Sofa designed with AI, reduced material used. The sofa is very light and the structure is designed to make it easy to assemble and reassemble it.		✓							
Switzland	Vitra	Take back the used furniture from events and exhibitions, as well as from consumers to resell.					✓				
United Kingdom	Benchmark	100% transparency. They consider the materials used, the products, and the way they make them, as well as how they manage the workshops and waste.									✓

<sup>1</sup> M and C = materials and components; <sup>2</sup> PM = product manufacturing; <sup>3</sup> PL = product lifecycle; <sup>4</sup> POS = product-oriented service; <sup>5</sup> BMP = business model pattern; <sup>6</sup> SVOP = shared value-oriented process; <sup>7</sup> EA = ecosystemic awareness across inter/intra stakeholders; <sup>8</sup> EPF = ecosystemic problem framing with inter/intra stakeholders; <sup>9</sup> EOOS = ecosystemic-oriented organizational solutions.

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