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Connecting Natural Fibers and Territories Through Design: The Case of Hemp and Bamboo for a Sustainable Made in Italy

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Abstract
This paper presents the research project Circular Design for Natural Fibers (CD4NF), which promotes the transition towards Circular Economy practices in Made in Italy productions across the furniture, textile, and construction sectors, focusing on the use of natural fibers derived from the Italian agro-industrial system. The study explores how the development of new bio-based materials and products — framed within sustainability principles and aligned with Circular Economy and Circular Design approaches — represents a dynamic area of debate for the design discipline, raising critical questions around technologies, contexts, and development paths. The paper also illustrates the design-driven methodology adopted in the project, particularly in the application of systemic design to the cases of bamboo and hemp and discusses its integration with contributions from other disciplines. Finally, it emphasizes the connection between local supply chains and their territories, understood not only as productive ecosystems but also as expressions of cultural heritage, thereby enhancing the value of Made in Italy design.

Keywords
Systemic Design
Material Culture
Value Chain
Hemp
Bamboo

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INTRODUCTION

This research is built upon the use of natural fibers as drivers for a sustainable and circular transition of productive systems within the Italian context. In a world where current economic and productive processes pollute soil, water, and air consistently and globally, investing in local materials and circular practices becomes mandatory.
Technological innovations play a pivotal role in facilitating this transformation. However, the socio-cultural assets of supply chains, as well as their intangible heritage made of technical knowledge and historically shared practices, must also be considered. Natural materials are closely intertwined with local conditions and the knowledge of the territories concerned, and within this framework, the design-driven project must be able to integrate these facets.
The Circular Economy (CE) paradigm, on which Europe has been investing through programs and policies since 2015 (European Commission, 2020), promotes 'closing the loops' of material flows while reducing waste from production processes (Blomsma and Brennan, 2017; Corvellec et al., 2020). Grounded in sustainability, resilience, resource optimization, and waste management, CE encourages approaches that reduce environmental impacts while fostering economic growth (Kirchherr et al., 2018). Within this scenario, a Systemic Design approach (Bistagnino, 2011; Battistoni et al., 2019) can contribute significantly to achieving CE goals, enabling input-output resource flows, connecting local stakeholders, and unlocking hidden territorial assets.
This approach was adopted in the Circular Design for Natural Fibers (CD4NF) project, which aims to rediscover the use of either wasted fibers or virgin 'forgotten' and 'new' fibers (including hemp, nettle, bamboo) to create innovative materials, bio-inspired composites, components, semi-finished products, and services for the textiles, furniture, and construction sectors.
Italy has a long tradition in the use and processing of natural fibers, such as wool and hemp, which declined after the 19th century with the rise of synthetic fibers and the globalized economy. Recently, interest in local and natural fibers for industrial uses has re-emerged, aligning with the Green New Deal and the New Circular Economy Action Plan.
The growing role of natural fibers in the Design field is evident in increasing publications, ranging from articles to books, involving both industry and designers as producers and transformers of circular materials. Recent exhibitions such as *Life Cycles: The Materials of Contemporary Design* at MoMA and *Intelligens. Natural. Artificial. Collective* at the Venice Architectural Biennale, particularly the *VAMO* project curated by ETH Zurich with MIT, show how material research must address the design of processes and supply chains. With the neologism 'fiberscape' — related to the perspective of 'scaping', i.e. the experience of what can be seen, smelled, and felt in the domestic landscape — we refer to this emerging experimental context in which the use and diffusion of fibers require rethinking supply chains.
This research addresses process design as a methodological approach for change and innovation within the Made in Italy context, introducing new methodologies and tools for design-driven innovation. The article develops through four interconnected sections: Section 2 examines the historical trajectory of natural fibers in the Made in Italy ecosystem; Section 3 presents the CD4NF project and two case studies, hemp and bamboo; Section 4 discusses the role of design as mediator between retrospective innovation

rooted in tradition and prospective innovation oriented toward future opportunities. The conclusion reframes the territory as an active agent enabling cultural, technological, and systemic shifts toward circularity.

NATURAL FIBERS AND MADE IN ITALY: A LONG TRADITION

To frame the phenomenology linked to the use of fibers in Italian design, it is useful to recall how the valorization of production chains connected to natural fibers, and their know-how, has deep historical roots. Aimed at producing furniture and everyday objects, this attitude can already be traced back to the inter-war years when institutions such as Enapi (Ente Nazionale Artigianato e Piccole Industrie, founded in 1925 and active until 1975) promoted natural fibers through publications like *Prodotti italiani d'intreccio* (1932). In these years a collaboration emerged between architect-designers and craft workshops, first within the context of *design autarchico*, and later returning to a focus on fibers in the post-war period. Weaving, for instance, appears in the straw seats of Gio Ponti's *Leggera* and *Superleggera* for Cassina — examples of mechanized craftsmanship applied to serial production—as well as in special pieces by Franco Albini and Franca Helg for Bonacina, or in Roberto Mango's conical *Sunflowers* armchair in woven wicker or hemp rope.
Craftsmanship — what today would be considered excellence — was also central in the selection of products displayed in the travelling exhibition *Italy at Work* (1950–1953), which toured major U.S. cities. Furniture, accessories and objects from Florentine workshops such as Raffaello Bettini and Emilio Paoli gained visibility and contributed to promoting Made in Italy abroad (Cordera & Turrini, 2025). Although still tied to folklore, these works helped, as design historian Penny Sparke notes, transition traditional craftsmanship into the more conscious domain of the 'craft arts' between the 1940s and 1950s (Sparke 2014). These productions appeared at the 1951 Milan Triennale (in the exhibition curated by Reggio and Calderini) and received wide diffusion in magazines such as *Domus*, eventually drawing the attention of large retailers. For example, in 1956 La Rinascente in Milan organized *Italia Espone*, curated by Giancarlo Iliprandi, showcasing straw, wicker, raffia, reed and marsh reed objects.
Alongside this cultural and design-driven legacy, natural fibers also played a key role in Italy's productive history. Hemp is a primary example. Before 1960 Italy was the world's second-largest producer after Russia, with over 90,000 hectares dedicated to fiber and textile cultivation. Italian hemp was internationally renowned for its quality, due to refined maceration and processing techniques (Giupponi et al., 2020). The Po Valley — especially Emilia-Romagna and Piedmont — was a major cultivation area, known for the prized 'Carmagnola' variety, while southern regions such as Campania and Basilicata also contributed (Sorrentino, 2021). Production sharply declined after 1960 due to two converging factors: the spread of synthetic fibers and the introduction of international regulations.
Between art and design, some experiments emerged, such as Bruno Munari's 1965 series of bamboo vases for Danese, made from unused cane parts with the collaboration of a Japanese craftsman, still relevant for their technological insights. In the 1970s, natural fibers found a place in luxury interior and furniture production, visible in Gabriella Crespi's works and in series like

Brasilian (bamboo and malacca) by Afra and Tobia Scarpa for B&B Maxalto (1975), produced with the Philippine Company. The 1980s and 1990s, driven by market internationalization and the arrival of foreign designers with new aesthetics and cultures, encouraged an 'ethnic' taste seen in Cappellini's *Mondo* collection (1988) or in Driade's diversified offer.
With the new millennium, the term *glocal* replaced 'ethnic' to describe objects such as those by Fernando and Humberto Campana, which create a short circuit between distant imagery and local production (e.g., the *Bambù* lamp for Candle or the *Cabana* cabinet for Edra in viscose raffia). These practices can also be read through the lens of a 'native' aesthetic — associated with a form of native ecologism applied to design — discussed by Trini Castelli (1995).
This brief historical excursus highlights both the significance of fibers for design culture and their role in renewing local knowledge within global scenarios. It also shows how natural fibers support experimental design and new production paradigms, enabling the rethinking of materials for multiple applications and new value ecologies.

THE CONTEMPORARY "FIBERSCAPE"

The contemporary "fiberscape" defines a new paradigm for designing fibers and with fibers, characterizing the last twenty years and offering a relevant research direction.
The 'native' language that marked the end of the millennium opened new horizons for the iconography of materials in their natural or minimally transformed state. What appears new today, however, is how research on natural materials intersects with broader reflections on circular processes and the adoption of syntropic models that inherently require plural practices.
These practices begin with the co-design of supply chains and with attentive observation of territories and their material cultures. More than a project, the fiberscape is a horizon — a landscape in which different components form both a result and an intentionality.
Numerous start-ups and entrepreneurial initiatives have emerged to promote CE, demonstrating that design can play a central role in transforming the economic model toward circularity. An example is the *Syntropia* project (2021)



Fig. 1
***Syntropia* project (2021) represented by Eugenia Morpurgo**

represented in **Fig. 1**. Developed by Eugenia Morpurgo, footwear designer Sophia Guggengerger, and an interdisciplinary team — covering software, materials, 3D printing and agronomy — the project investigates methodologies for designing footwear in dialogue with the agricultural ecosystem of biomass. As part of broader research on "Syntropic Materials", it explores the connection between agroecological practices and cutting-edge natural material research. Agricultural waste, often considered worthless, includes residues from cultivation to industrial processing that must be discarded. Yet these by-products are potentially valuable and require not only transformation into new materials but integration into sustainable processes for communities.
This case study exemplifies new eco-conscious manufacturing and demonstrates how natural fibers in design have played — and continue to play — a role of cultural mediation and resistance to uncritical modernization trends through interconnections between territories, spaces, people, materials and knowledge (Scodeller & Mancini, 2023).

THE CIRCULAR DESIGN FOR NATURAL FIBERS PROJECT

The CD4NF research was structured into four phases. The first phase involved the framing and contextualization of the topic through a review of scientific and grey literature on fibers and their supply chains, the analysis of statistical data concerning the quantity and distribution of cultivation residues and supply chain waste, and the chemical characterization of fibers. The second phase focused on analyzing case studies related to the development of design solutions aligned with CE processes. This phase enabled the definition of design scenarios concerning (i) new bio-based materials and (ii) tools for enhancing and assessing the economic, environmental, and social sustainability of the proposed solutions.
The fibers examined in the research originate from territories distributed across Italy, from north to south. The geographical mapping includes wool from indigenous sheep and prickly pear blades in Sicily, olive waste in Apulia, hemp cultivation in Tuscany, sugar beet processing residues in Emilia, secondary materials from rice and corn production, as well as poplar plywood processing in Piedmont, where several bamboo plantations are also located. **Fig. 2** illustrates the geographic distribution of the fibers analyzed and the related types of bio composite materials produced.

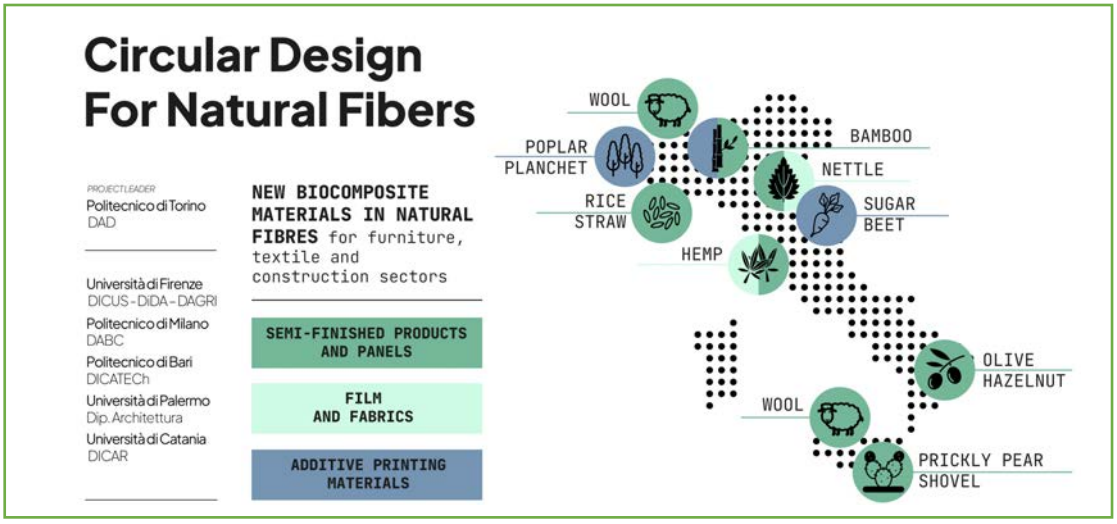


Fig. 2
Geographic distribution of the fibers analyzed in Italy, and the related types of bio composite materials produced

This material diversity corresponds to the geographical distribution of the universities involved, which collaborated through a multidisciplinary approach integrating architecture, design, and chemistry. Design and architecture researchers primarily addressed supply chain analysis and the definition of design scenarios for fiber valorization. Starting from the recovered fibers, chemical analyses were carried out to support biomass valorization — from fiber characterization and pre-treatment to component separation — leading to the production of laboratory samples of bio-based materials such as panels and films.
This phase resulted in a collection of 16 biomaterial samples. Twelve of these consist almost entirely of natural fiber, used both as matrix and reinforcement, while in the remaining four samples natural fibers act as performance enhancers in polymers (bio-resin and PLA), generating semi-finished products and additive manufacturing materials.
Subsequent sections focus on two specific case studies — hemp and bamboo — directly investigated by the authors. The analysis explores supply chain structures, highlighting limitations, opportunities, and strategies for development and innovation, together with the related research outputs.
Finally, the discussion chapter offers a critical reinterpretation of the results from a systemic design and design-driven perspective, comparing them with the broader 'fiberscape' phenomenology previously introduced. The aim is to identify strategies and processes through which design can foster the use of natural, sustainable, and Made in Italy materials, thus supporting the transition toward a Circular Economy and enabling technology transfer within Italian industrial and craft sectors.

CIRCULAR HEMP SUPPLY CHAIN THROUGH SYSTEMIC DESIGN

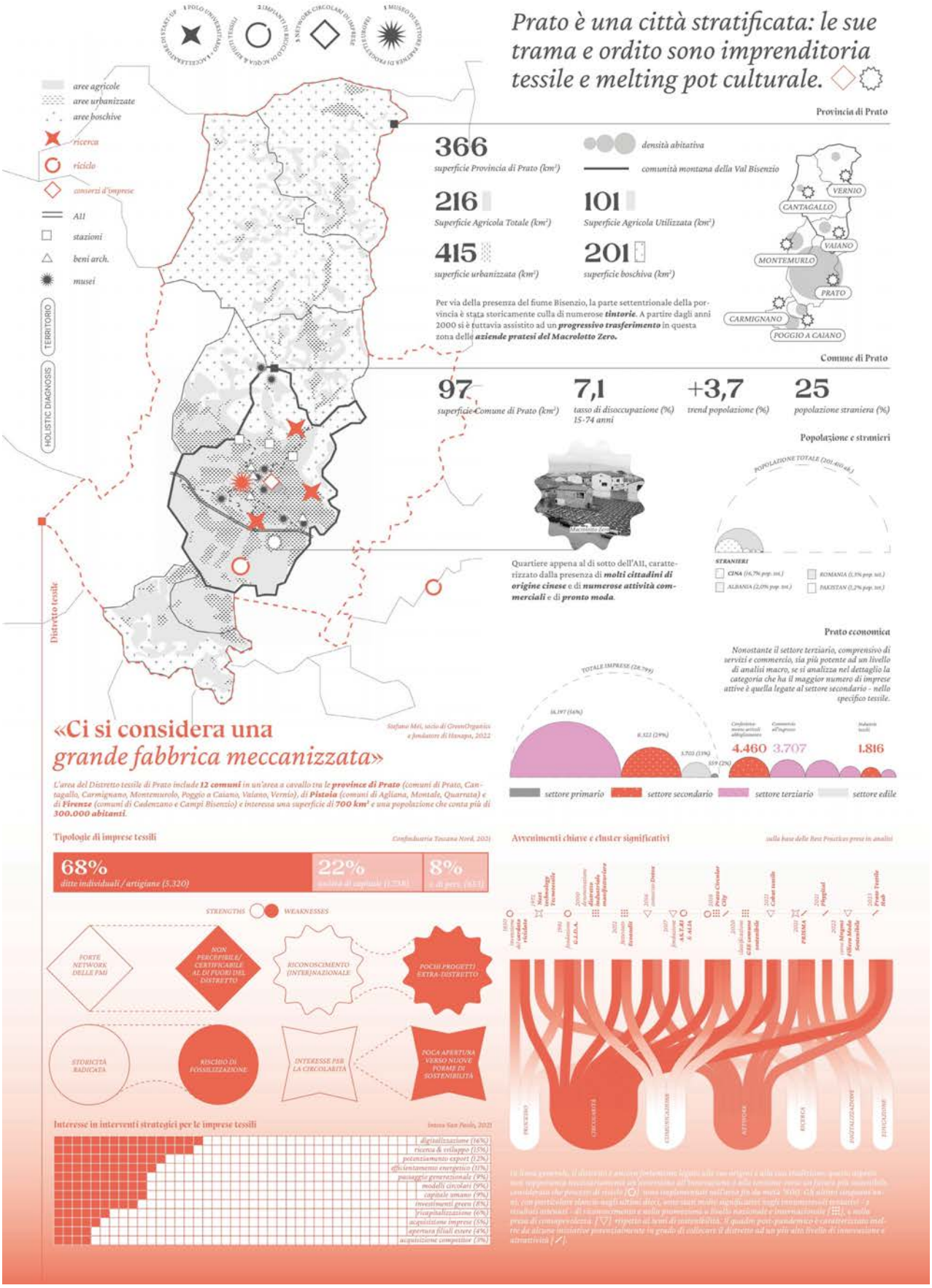
As part of the Circular Design for Natural Fibers project, the team adopted Systemic Design as a strategic methodology to regenerate local supply chains for natural fibers — specifically hemp in the Prato textile district and bamboo in Central and Northern Italy. Systemic Design addresses complex, multi-actor systems by reorganizing material and information flows to enable circularity, transforming outputs from one process into resources for another (Bistagnino, 2011). In doing so, it provides a framework for reconfiguring traditional take-make-dispose value chains into collaborative, regenerative ecosystems capable of reducing waste, emissions, and economic inefficiencies.
Hemp has recently attracted attention across academic, political, and industrial domains due to its versatility, short cultivation cycle, and carbon-sequestering capacity (Ahmed et al., 2022), which make it relevant for multiple Made in Italy sectors. Indeed, its components — from roots to leaves — can be fully used for many industrial applications (Ahmed et al., 2022; Kaur & Kander, 2023). Despite its potential, hemp's value chain faces major challenges. First, there is a lack of clear legislation and agricultural standards (Giupponi et al., 2020). Furthermore, the limited presence of operational primary processing sites (Sorrentino, 2021), as well as a lack of modern and specialized machinery for its processing, makes the process economically unprofitable (Zimniewska, 2022). Additionally, there's a shortage of experienced hemp farmers and limited brand investment (Giupponi et al., 2020) resulting in high dependency on foreign suppliers, mainly China and

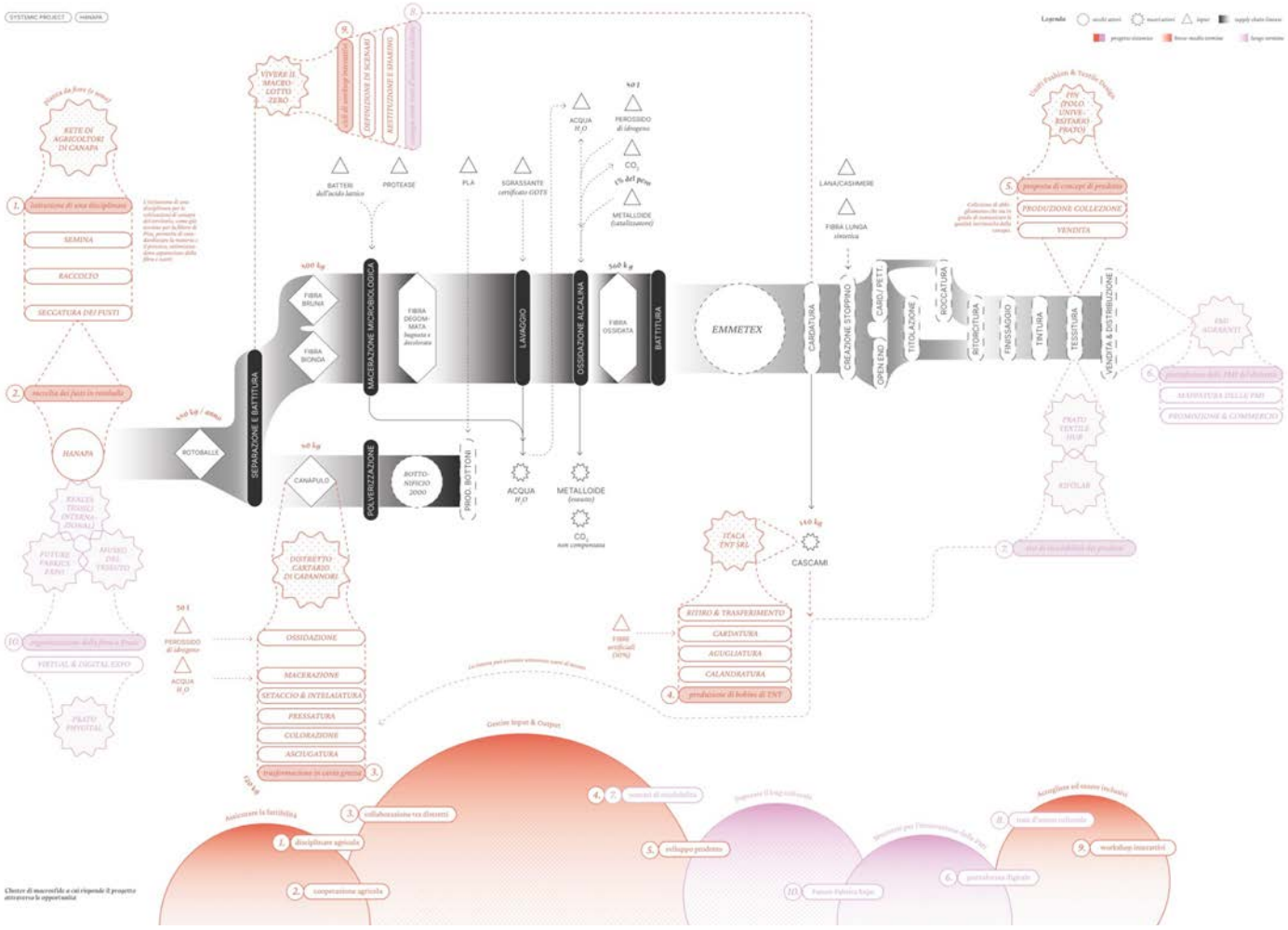
France, despite the great suitability of Italian land for hemp cultivation. On a cultural point of view, there's still a spread of prejudice that incorrectly identifies hemp with drugs, inhibiting R&D activities and innovation (Amaducci, 2005; Chandra et al., 2017).
In response, the project envisioned a fully integrated, circular hemp supply chain embedded in the Prato textile district, Europe's leading hub for textile processing, recycling, and circular economy practices. This location enabled the activation of a network of technological, human, and industrial resources to support feasibility. By applying Systemic Design, the team aimed to create synergies among agriculture, textiles, bio composites, and bioconstruction, enhancing regional resilience and unlocking new cross-sector business models.
The design process unfolded in three interconnected phases. First, the team carried out a Holistic Diagnosis (Battistoni et al., 2019). This method combines desk and field research to collect and process economic, historical, social, environmental, and technological data to guide context-based design choices. We elaborated and synthesized this data using Gigamaps (Sevaldson, 2011), visual representations that help to identify relationships, material flows, and the key interdependencies across a territorial system (Barbero, 2017; Pereno & Barbero, 2020). Based on this analysis, we identified leverage points that revealed both critical issues and untapped opportunities, informing the definition of targeted strategies to foster circular business models. Fig. 3 shows the Gigamap of the territorial context, providing a state-of-the-art overview of the area and supporting context-based design decisions. Fig. 4 illustrates the hemp productive process, highlighting waste streams (e.g., shives, short fibers) and potential valorization pathways, such as paper, bio composites, and insulation.
Building on these insights, the team developed two Proofs of Concept (POCs). At the value-chain level (POC1), we designed a circular hemp supply chain in the Prato district by connecting complementary industries. The proposal integrates a paper manufacturer capable of reusing hemp shives, a non-woven textile company able to upgrade short fibers through mechanical or chemical processes, and a furniture company that can test the resulting materials for upholstered products. This configuration demonstrates how local actors can jointly valorize hemp residues and contribute to a resilient, economically sustainable supply chain. The tangible outputs of this phase are the 4 Gigamaps, depicting the various material flows, the value chains' interconnections and the stakeholders mapping.
At the product level (POC2), we focused on enhancing short hemp fibers — an abundant by-product of CBD cultivation that is currently discarded and not considered suitable for textiles. In collaboration with the Department of Chemistry U. Schiff at the Università di Firenze[1], we developed an organic non-woven fabric produced by binding short hemp fibers with a cellulose-based agent extracted from the same plant through biorefinery processes. The resulting material is intended for use as an interior covering for upholstered furniture, offering a bio-based alternative to polymeric non-wovens currently used in the sector.

[1] The researchers involved are Salvini A., Cappitti A., Vespignani L., Matassini C., Pratesi D, Bonini M, Tonelli M. (Università di Firenze)

Fig. 3

Gigamap of the Prato (IT) territorial context, providing a state-of-the-art overview of the area and supporting context-based design decisions





Overall, the Systemic Design approach enabled not only technological and material innovation but also a broader cultural and industrial shift. By reactivating local knowledge, building new collaborative networks, and reconnecting traditional practices with contemporary circular strategies, the project laid the foundation for territorially grounded, sustainable business models capable of supporting long-term ecological and economic transition.

Fig. 4
hemp productive process, highlighting waste streams (e.g., shives, short fibers) and potential valorization pathways, such as paper, bio composites, and insulation

INTRODUCING BAMBOO MADE IN ITALY: A CONTROVERSIAL STORY

Liese et al. (2015) report over 1,000 documented uses of bamboo worldwide, particularly concerning the culm. All parts of the plant can be employed without generating production waste. The plant's physical and chemical properties, together with its mechanical performance, make bamboo particularly relevant for architecture and design (Deng et al., 2023), especially due to the balance between lightness, mechanical strength and flexibility of the culm. These characteristics explain both its extensive global use (Md Tahir et al., 2023) and its potential relevance for the Italian manufacturing sector. Globally, bamboo plantations are considered a non-woody ‘second forest’ with a significant impact on CO_2 absorption, especially since bamboo culms regenerate annually. For this reason, bamboo is recognized as a renewable

raw material that can contribute to climate and environmental sustainability goals (INBAR, 2015) and other SDGs (Baharuddin et al., 2023).
In Italy, bamboo is not autochthonous but adapts well to local climatic conditions. Its introduction as an agro-industrial crop is relatively recent (10–15 years), and the most cultivated species is Phyllostachys edulis or pubescens, known as Moso (Lombardo, 2022). According to Somaschini (2017), plantations covered around 1,500 hectares in 2017. Although the diffusion of plantations is not monitored nationally, the Italian raw material supply chain is expanding, albeit fragmented. Interest in the plant is also reflected in the presence of at least seven Italian consortia and one national association dedicated to promoting bamboo cultivation. Imports further confirm its relevance: TRADEMAP.org reports a total value of imported bamboo in 2022 of approximately EUR 88.5 million.
Based on these premises, the researchers conducted a systemic analysis of the Italian bamboo supply chain to explore opportunities and constraints affecting its diffusion. The study was developed in collaboration with the Made in Bamboo (MiB) network of companies based in Turin, which includes fifteen growers, nurserymen, agronomists, designers and experts from northern and central Italy. Fig. 5 shows one of the MiB's bamboo forests near Turin. This collaboration made it possible to understand the current system of production, marketing and processing, and highlighted lesser-known aspects of the ongoing Italian debate on bamboo, including the different commercial narratives surrounding it.



Fig. 5
bamboo forests near Turin (IT) part of the Made in Bamboo network

The first key finding is that a fully developed Italian bamboo manufacturing supply chain does not yet exist. Despite growing raw material availability, the number of enterprises processing bamboo remains limited and predominantly related to craft production of outdoor furniture and custom installations.

Conversations with MiB artisans highlighted that processing bamboo requires specific technical skills unfamiliar to Italian craft traditions. Although bamboo shares some affinities with wood, its processing techniques differ considerably, and the intrinsic irregularity of bamboo culms — contrasting with the geometric regularity of wood semi-finished products — demands distinct manufacturing strategies. The lack of dedicated skills also limits the development of products aligned with the formal aesthetics and design languages typical of Italian manufacturing. In response to this underdeveloped material culture, the research explored material experimentation on the lower part of the culm, a secondary by-product of harvesting. The experiments, shown in Fig. 6, indicated the suitability of more regular semi-finished elements derived from culms, such as “splits” — long, narrow, flexible strips — particularly appropriate for weaving techniques more widespread in the Italian tradition.



Fig. 6
material experimentation on the lower part of the bamboo culm, a secondary by-product of harvesting

The second key finding concerns the cultural ‘acceptance’ of bamboo. Although internationally recognized for its environmental, economic and social sustainability (INBAR, 2015), Italian debates are marked by contrasting positions: one optimistic and one skeptical. The optimistic view emphasizes positive features such as high CO_2 absorption and plantation productivity, low maintenance and significant earnings five years after investment. Conversely, the skeptical position focuses on bamboo’s invasiveness and its non-endemic nature, perceived as potentially harmful to landscapes and biodiversity. The discovery of such prejudices and misinformation led the researchers to focus on promoting non-superficial, non-stereotypical knowledge of the plant. Given the increasing interest in bamboo, addressing cultural aspects may facilitate the establishment of a national supply chain.
The research aimed to evaluate the sustainability of bamboo in Italy not only from an environmental perspective — as previously studied by Vadalà et al. (2022) and Marchi et al. (2023) — but also from economic and social viewpoints. Using measurable data directly provided by MiB, the research

group developed a multi-criteria assessment model integrating LCC, LCA, and sLCA methodologies[2]. The findings confirm several aspects of bamboo's sustainability, particularly regarding its environmental impact. For instance, the cultivation of one kilogram of bamboo generates 0.1 kg of CO_2 equivalent, compared with steel, which has a ratio of 1 to 0.7 (WWF Italy, 2024). Overall, the proposed evaluation model provides a rigorous scientific framework and a decision-making tool for growers, producers, and policymakers.

DISCUSSION: INNOVATION THROUGH TRADITION

The cases presented allow reflections on design-driven processes and strategies to promote a sustainable transition through the valorization of local natural materials in close dialogue with their territories of origin.
In the case of hemp, innovation derives from reactivating a fiber historically central to Italy, particularly in the early 20th century. By recovering lost knowledge of cultivation, transformation, and use, the project promoted circular innovation grounded in territorial identity and cultural continuity. The design process thus combined technical optimization with social and symbolic value, reconnecting with local know-how and regenerating the supply chain as an integrated ecosystem of practices. Conversely, the bamboo case focuses on a 'new' resource, aiming to enhance its unique properties while aligning with Italian material culture. Design also contributed to addressing ambiguities around the plant's cultural acceptance and sustainability. The multicriteria assessment model developed is highly contextualized, co-designed with local stakeholders to integrate scientific expertise and sector knowledge.
In both cases, design proposals emerged through engagement with supply chain actors and through material and technological experimentation on raw fibers. The aim was to demonstrate concrete possibilities for innovating with locally available materials, skills, and knowledge.
A shared aspect across hemp and bamboo concerns the interplay between raw material availability and skilled craftsmanship. Despite Italy's historical competitiveness in hemp, its current value chain is fragmented due to legislative, productive, and knowledge-related challenges, frustrating farmers and brands investing in the crop. For bamboo, the increasing national raw material supply contrasts with the scarcity of skilled processors. Project experiments are therefore returned to the field to co-design practical applications with local actors, considering existing technologies and skills. Redesigning supply chains benefits from artisanal rather than industrial processes, favoring small-batch production. This 'diffuse manufacturing' approach is adaptable to limited material quantities and opens opportunities for marginal territories excluded from large-scale industrialization (Scodeller, 2023).
Another shared challenge is cultural acceptance. Hemp's historical association with drugs has hindered development and research, despite a domestic market that imports semi-finished hemp products from China and France. Bamboo, although globally recognized for sustainability, faces skepticism due to its non-native status. In both cases, imports of finished

[2] The researchers involved are E. Fregonara, F. Thiebat, R. Giordano, A. Masoero, C. Senatore, M. A. Muñoz Veloza, F. Morselli (Politecnico di Torino).

products indicate domestic appreciation and latent market potential that could be better exploited using local raw materials.
From a design-driven innovation perspective, the production of raw materials is critical. Many historical supply chains have been dismantled over the last decades, creating challenges in material availability. A Systemic Design approach, encompassing the supply chain from field to consumer, must consider that the availability of natural materials depends on crop planning, plantation management, and alignment with public incentives and regulatory frameworks.

CONNECTING TEMPORALITIES THROUGH DESIGN

The aspects discussed above influence the development of sustainable supply and production chains and their potential environmental, economic, and social benefits for territories and communities. The case studies presented highlight the role of design as a key facilitator of innovation, positioned between two complementary temporal approaches: one retrospective, rooted in tradition, and one prospective, oriented toward new, less explored processes and languages. Design thus acts as a cultural, strategic, and systemic mediator, capable of reinterpreting past knowledge while opening space for future experimentation. This is evident in the case studies presented in the first part of the article, where natural raw materials are used consciously, combined with local craft skills and know-how. By interpreting the connection between native materials and local expertise, design can strengthen production and transformation chains, enhancing their value.
This design approach exemplifies what recent literature defines as ‘innovation through tradition’ (De Massis et al., 2016; Gusenbauer et al., 2023), framing innovation as emerging from tradition through recovery, reinterpretation, and strategic reuse of historically embedded knowledge, materials, and practices. As Petruzzelli et al. (2012) note, tradition includes know-how, manufacturing processes, cultural values, and symbolic meanings transmitted across generations, forming a fertile ground for innovation when designers and local actors engage in temporal reinterpretation. This perspective aligns with the historical trajectory of Made in Italy, which has long drawn strength from artisanal expertise, local social capital, and distributed production models rooted in territorial specificity (Piore & Sabel, 1984; Becattini, 1991). Success in sectors such as textiles and furniture relied on transforming tradition into competitive advantage through dense networks of SMEs and micro-enterprises that preserve craftsmanship while interpreting it with contemporary design languages. Today, in a globalized, digitalized, and environmentally pressured context, this temporal symbiosis — combining retrospective and prospective approaches (Erdogan et al., 2020) — remains a strategic lever for innovation within complexity.
By operating within this tradition-aware and place-based framework, design contributes not only to technical material regeneration but also to cultural and organizational transformation of production models. It offers a pathway to sustainability that does not erase historical knowledge but reactivates it, enabling territories to reclaim agency in shaping their future. This approach is especially relevant in Italy, where productive cultures remain deeply

connected to local identity, and social capital and embedded know-how continue to strengthen supply chain resilience. Design, in this sense, mediates between tradition and innovation, enabling their co-evolution and shaping sustainable futures rooted in past resources.

CONCLUSION: RESTARTING FROM THE TERRITORIES FOR A MADE IN ITALY CULTURALLY SUSTAINABLE

In the context of experimentation with natural fibers, the CD4NF project developed design strategies to promote the use of natural, sustainable, and Made in Italy raw materials. The research highlights the potential of a new material-production paradigm based on local natural fibers, addressing two key aspects: the environmental and social sustainability of materials as alternatives to more impactful ones, and the enhancement of local production chains in the agro-industrial sector, which also culturally characterize Italian territories.

Design-driven and systemic approaches are essential to foster ecosystemic visions of transition. Future research aims to identify development strategies for new products in the furniture and architecture sectors, connecting small and medium-sized agri-food industries with local craftsmanship. The goal is to translate laboratory experiments with hemp, bamboo, and other fibers into territorial applications, leveraging technological and cultural resources while promoting the craft-oriented dimension of Italian design. As Lai (2004) noted, popular technical knowledge is dynamic, permeable to scientific and external technical influences, and prone to syncretism. This aligns with the concept of a 'soft economy,' based on knowledge, innovation, identity, history, creativity, and quality, which underlies the meaning of Made in Italy as an economy capable of combining social cohesion and competitiveness through community and territorial strength (Cavalli et al., 2014).

Reflection on the role of design in supporting sustainable and circular transitions emphasizes the centrality of the territory in fostering innovations rooted locally. The value of the territory in connection with fibers and their integration into a system promoting and revitalizing Made in Italy can be recognized in three directions: first, as a source of raw materials, recognizable techniques (*savoir-faire*), and stratified cultural history; second, as a network of human and professional relations in which design-driven approaches reinterpret, transmit, and connect tradition and innovation through new products, processes, and systems; and third, as a heritage of environmental, cultural, and qualitative value.

By highlighting the territory's multifaceted role, the CD4NF project underlines how design can mediate between experimental material research, local craftsmanship, and broader socio-cultural and environmental objectives, fostering a circular and sustainable design culture firmly rooted in Italian identity.

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