SYSTEM DESIGN FOR THE SUSTAINABLE ENHANCEMENT OF ITALIAN WOOL PRODUCTION CHAIN

THE INTEGRATED APPROACH OF FILA NATIONAL OBSERVATORY PROJECT

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Abstract

The Italian wool industry is facing considerable challenges, largely due to mounting environmental concerns that are undermining its economic viability and sustainable production management. This paper presents the strategy of the FiLA National Observatory project, launched in 2024. The project objective is to reconfigure the value creation processes through a circular economy approach for the indigenous wool supply chain, establishing an energy-neutral, human-centred, and inclusive model. Italian wool (20-30 μm) is facing significant challenges in the international market, particularly from finer New Zealand wool (15 μm). Additionally, approximately 10,000 tonnes of annual greasy wool production is often treated as special waste, highlighting the urgent need for a systematic intervention to understand the strategic positioning of Italian wool within the broader context of the textile supply chain. This should extend beyond fashion and knitwear design to encompass a wider macroeconomic landscape. By 2025, the FiLA Observatory will develop a digital platform to support networking and system competitiveness, promoting innovation in processes, products, and services. Through mapping actors, identifying research opportunities, and defining macro-economic trends, the project proposes a comprehensive model that integrates economic, productive, environmental, and social aspects, ultimately contributing to a new paradigm of prosperity in the fashion industry.

Keywords: *Design Driven Innovation, System Design, Circular Economy, Wool Supply Chain, Sustainable Production*

INTRODUCTION. THE FILA OBSERVATORY AS A SYSTEMIC APPROACH TO NATIVE WOOL SUPPLY CHAIN INNOVATION

The native Italian wool supply chain has recently become a key debate point, primarily due to two major factors. Firstly, there is the issue of its decline in global competitiveness, and secondly, the pressing need for revitalization to address growing concerns regarding sustainability. With approximately 6.5 million sheep producing around 10.000 tonnes of greasy wool annually, the industry represents a significant economic and environmental resource that is largely underutilized (Sanua et al., 2020). Historically recognized for its high-quality materials, Italian wool now faces substantial market challenges due to its fibre characteristics: with a fineness between 20 and 30 μm, it struggles to compete with imported New Zealand wool (approximately 15 μm) in premium textile applications, leading to market disadvantages despite significant transportation-related environmental impacts (Klepp & Tobiasson, 2022).

The European Regulation EC 1069/2009 classifies raw wool as a by-product of animal origin. This classification has transformed wool from a valuable resource into a disposal burden for farmers, imposing additional costs and environmental impacts, as argues the 2023 Textile Exchange, Materials Market Report. Furthermore, in September 2024 the Italian standardization system has introduced UNI 11952, a significant

regulatory development that specifically addresses sheep farming for wool production within a bioeconomic framework. This standard recognizes wool production as an "environmental product" intrinsically linked to grazing practices, which play a fundamental environmental role from fire control to weed reduction and pasture fertilization. While the standard implementation supports the extensive low-energy consumption breeding system typical of sheep farming, providing guidelines for animal welfare, environmental impact management, biosecurity, and product traceability, it also presents new challenges for farmers.

Meeting these requirements requires technical knowledge, management skills and economic resources that many farmers have difficulty acquiring, especially in a context where wool revenues are very low, and where the condition of farmers is therefore particularly precarious, making it difficult to sustain the investments needed to meet compliance requirements while continuing their essential role within a supply chain that was once considered a resource, but is now a problem to be solved.

Furthermore, the challenges faced by the Italian wool sector are further exacerbated by the fragmentation of the supply chain, characterized by a lack of coordination between the various stakeholders, including farmers, processors, producers and final processors, each of which faces distinct operational and economic pressures, which in turn give rise to inefficiencies in resource use and value generation. Finally, the current linear production model makes these issues more complex to manage, not favouring horizontal relational processes and contributing to waste generation and excessive energy consumption. This picture clearly indicates the need for a transition towards more sustainable practices.

In response to this context, the FiLA National Observatory project, launched in 2024 and funded by MICS - Circular and Sustainable Made in Italy, an Extended Partnership between Universities Research Centers and enterprises financed by Italian Ministry of University and Research (MUR) thanks to funds made available by the European Union under the NextGenerationEU (PNRR) program, proposes an evolved and up-to-date model of value creation reconfiguration processes. The project aims to establish a comprehensive platform to support networking and system competitiveness through innovation of processes, products and services, fostering a sustainable native wool production chain. Through a design-driven and systematic approach, the FiLA Observatory will map the relevant actors, identify promising research topics, and define macroeconomic and socio-cultural trends to foster sustainable development. The Observatory model will offer advantages for the wool sector, by enabling systematic data collection and analysis, facilitating knowledge sharing among diverse stakeholders, and providing a platform for coordinating innovation efforts.

Unlike traditional top-down regulatory approaches or market-driven solutions, an observatory can act as a neutral intermediary, fostering collaboration while respecting the autonomy of individual actors. Addressing existing knowledge gaps through coordinated observation and intervention can foster sustainability in the sector, even at the national level (Matlhoko, 2023; Gaddi, Mastrolonardo, 2024). The Observatory approach is particularly relevant for the wool industry due to its ability to address three critical needs: first, the need for improved coordination among fragmented stakeholders; second, the requirement for systematic monitoring and assessment of sustainability practices; and third, the importance of facilitating knowledge transfer and innovation across the supply chain.

METHODOLOGY FRAMEWORK

The theoretical framework of this research integrates multiple approaches to address the complexity of sustainable systems. Moving beyond traditional GDP centric models (Stiglitz, 2009), the project embraces Moore's (2023) vision of transitioning from pure economic growth to a broader concept of prosperity. This transition is particularly relevant in Fashion System value chains, where Fletcher (2011) advocates for a fundamental redefinition of success metrics to include social and environmental impacts.

The project adopts a systemic design methodology that frames the wool supply chain as an interconnected ecosystem where waste from one process becomes a resource for another. This perspective builds on Bistagnino (2009) system thinking for sustainability, which emphasizes the relationships between components rather than isolated elements. Verganti (2009) design-driven innovation strategies are integrated to ensure that technical solutions are accompanied by meaning-

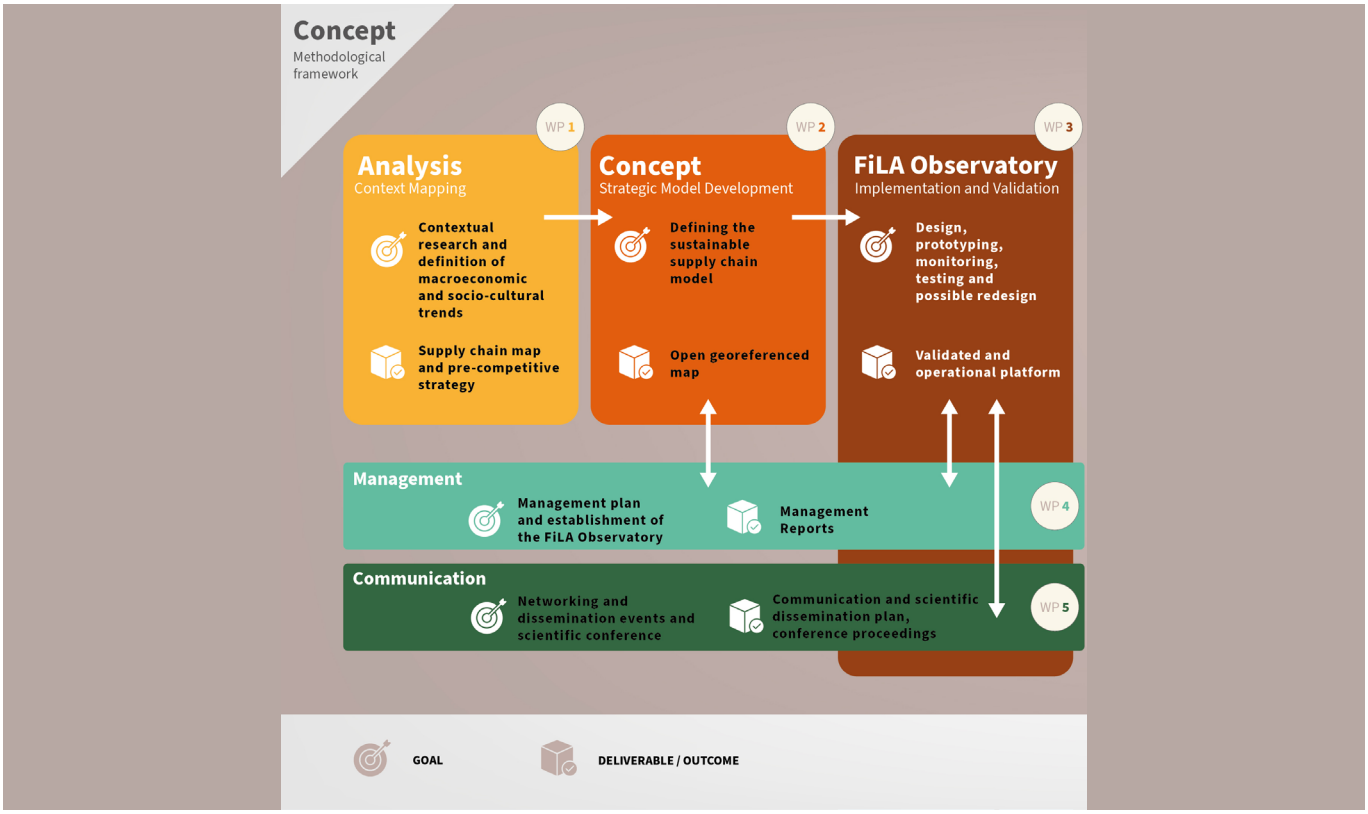

Fig. 01

ful cultural and social innovations. The approach is further grounded in Magnaghi (2020) territorial development strategies, recognizing the crucial role of local contexts and community engagement in sustainable development.

The methodology synthesizes three complementary theoretical streams. Industrial ecology principles (Frosch, 1992), provide the foundation for understanding material and energy flows within the system, while Ayres (1994) integrated industrial symbiosis framework guides the development of mutually beneficial relationships between different actors in the supply chain. These technical approaches are complemented by Wenger (1998) community-based economic models, which emphasize the importance of social learning and collective action in achieving sustainable transformations.

As shown in Figure 01, the research methodology unfolds through three interconnected phases, each building upon the previous while maintaining flexibility for iteration and refinement. The analysis and establishment of context is the foundation for the subsequent engagement with stakeholders and system analysis. This includes detailed mapping of material flows, energy usage, and waste streams within the current wool supply chain. International best practices are evaluated against local conditions to identify applicable innovations and potential barriers to implementation.

METHODOLOGIES FOR DATA COLLECTION AND ANALYSIS

The research phase of data collection, that is -at the time of concluding this paper- in the final phase of its analytical part, used a mixed approach to obtain both quantitative metrics and qualitative insights along the entire wool supply chain. The mixed approach was dictated by reasons related to the need to relate quantitative numerical data to the fundamental relationships between stakeholders and actors of different hyper-local territories, often linked by relationships of proximity and territorial belonging. To meet this important need dictated by a fragmented supply chain, stakeholders' interviews were conducted as a basis for the collection of qualitative data, involving various actors of the supply chain, from shepherds to textile producers. These specific interviews explored operational challenges, innovation opportunities and stakeholder perspectives on sustainabili-

ty, providing a rich contextual understanding of the dynamics of the sector.

The quantitative analysis of the supply chain, on the other hand, integrated the findings of the previous qualitative approach by considering production processes, material flows, production costs and market dynamics. This analysis incorporated multiple streams of data, including production volumes, processing capacity and market prices, allowing the identification of critical inefficiencies and potential intervention points within the supply chain. The cross-referencing of quantitative and qualitative data allowed for the integration and verification of cases where innovative processes and sustainability requirements were implemented alongside traditional practices.

A certainly relevant case study that emerged from the intersection of the analysis of the international scientific literature and the evidence of an important critical issue, the lack of greasy wool washing centers on the national territory that have a sustainable approach both from the point of view of non-chemical waste and water consumption. In this context of analysis, as an example, we can mention the good practice adopted in Val Verzasca, in Italian Switzerland, where the Pro Verzasca Association has patented, with the support of the Professional University of Italian Switzerland (SUPSI), a washing plant capable of processing small quantities of wool, obtaining a quality product comparable to that processed with industrial technologies intended for high-volume production, without the use of chemicals and with low energy consumption.

Following the principles and framework for Life Cycle Assessment described in ISO 14040, these assessments will also examine energy consumption, water use, chemical inputs and waste generation, providing quantitative measures for strategies to reduce environmental impact, including over the entire life cycle of the sheep.

This mapping will be made visible and communicable on the Observatory's web platform using Geographic Information System (GIS) technologies to provide a spatial understanding of the supply chain, documenting the distribution of resources, processing plants and transport networks. The aim is not only to visualise current supply chain configurations, but also to identify opportunities for the development of local clusters and collaborations between regions that have not previously been connected due to territorial distance. Life Cycle Assessment (LCA) references will be studied to assess the environmental impact of the entire wool production cycle.

In parallel, the identification and development of the strategic business model for the valorisation of the FiLA Observatory has followed a structured process that integrates economic sustainability with social and environmental impact considerations. The process began with a complete mapping of the value proposition for each category of stakeholder in the supply chain, from shepherds to final producers, focusing on transforming disposal problems into economic opportunities, while ensuring quality certification and territorial identity.

The model will enhance the exchange relationships between actors through differentiated levels of participation and innovation opportunities, defining the access to the services of the web platform.

The validation phase, which will be activated in the next steps of the project, will implement territorial pilots to verify the prices of the services, calibrate the relationship between the value generated and the management costs, and refine the service offer based on user feedback. The final model will therefore integrate the principles of circular economy, value sharing and social innovation, hopefully creating an economically sustainable system that supports the transition to more virtuous practices in the wool supply chain. Governance mechanisms will ensure a fair distribution of benefits among participants, with a particular focus on supporting more local, small and vulnerable production entities (Fig. 02).

INCLUSIVE APPROACH

The FiLA Observatory is an inherently inclusive network that fosters collaboration while preserving individual autonomy, thereby creating a balanced and sustainability-oriented ecosystem. In this ecosystem, each stakeholder maintains its independence while benefiting from collective resources and knowledge sharing. Consequently, participants can engage in collaborative initiatives while maintaining their unique market positioning and operational autonomy.

The network's design promotes sustainability by facilitating proximity-based collaborations, reducing transport impacts and strengthening local economic ties. Furthermore, the network enables

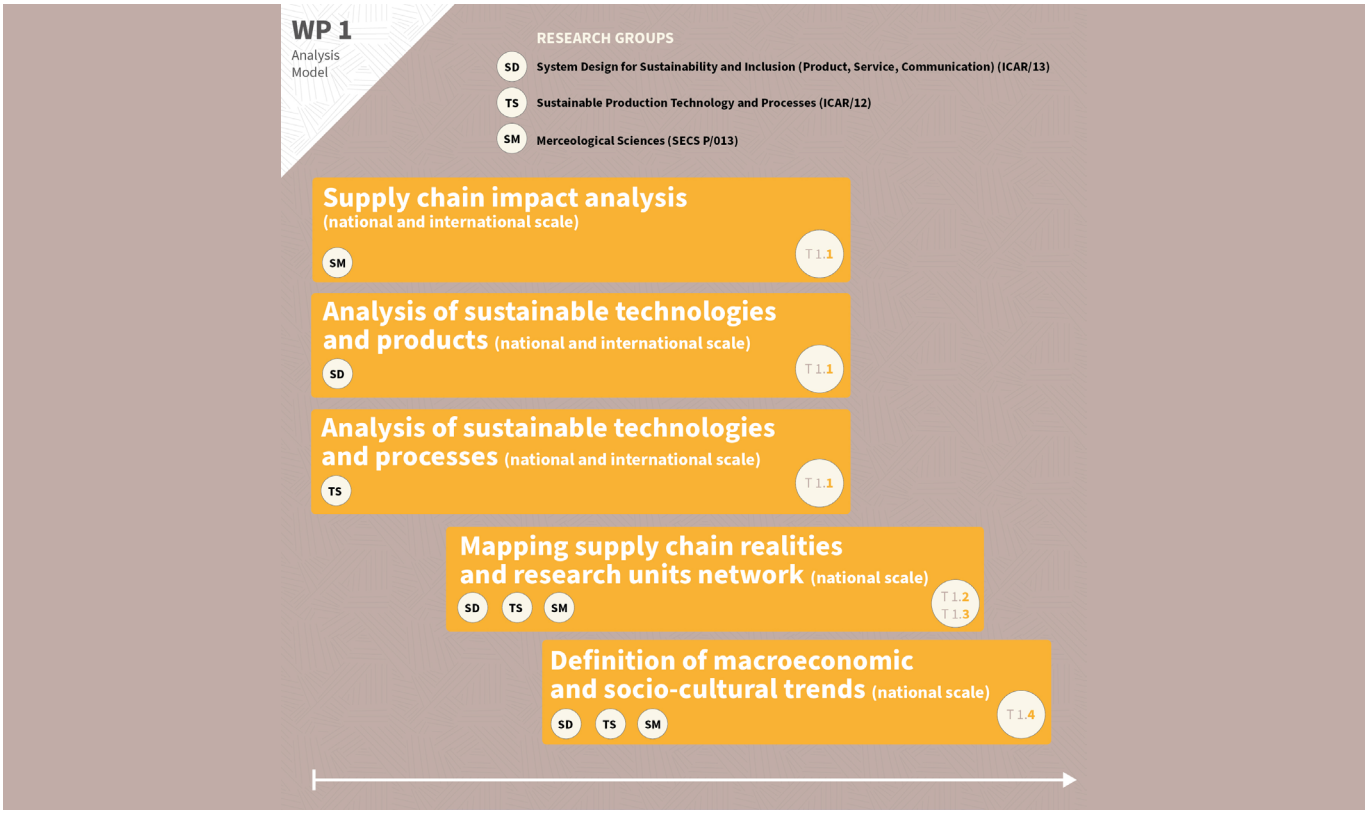

Fig. 02

the formation of micro-networks and horizontal clusters, creating supply chains that can better respond to market challenges. Finally, it provides a platform for sustainable innovation that emerges organically through stakeholder interaction and knowledge exchange.

This network structure demonstrates how systemic design methodologies can be applied to create sustainable value chains that benefit all participants, while promoting environmental stewardship and social responsibility. The model's success is predicated on its capacity to balance the needs of individual stakeholders with collective benefits, thereby establishing a framework for the long-term sustainable development of the wool sector.

The database creation process was structured following an integrated approach, in which good practices derived from the qualitative analysis of scientific literature on the specific context of the supply chain (addressed from the point of view of the analysis of impacts, sustainable technologies related to processes, products) and met and verified the quantitative data (the mapping of stakeholders) as shown in Figure 03.

MONITORING FRAMEWORK

The project implements a comprehensive bottom-up monitoring framework designed to track progress and impact across multiple dimensions of sustainability as social indicators, environmental performance and welfare indicators.

Social indicators focus on measuring the quality and extent of stakeholder engagement. These metrics include participation rates in network activities, collaboration intensity between different stakeholder groups, and the development of new partnerships. Knowledge sharing effectiveness is evaluated through tracking the adoption of best practices and the spread of innovations within the network. Cultural indicators assess the project impact on traditional wool-working knowledge and practices. These measures track the preservation and evolution of traditional techniques, the development of new skills among stakeholders, and the integration of innovation with cultural heritage. Learning outcomes are monitored through formal training participation and informal knowledge exchange within the community. Economic monitoring encompasses both traditional financial metrics and broader value creation measures. Beyond tracking direct revenue and cost implica-

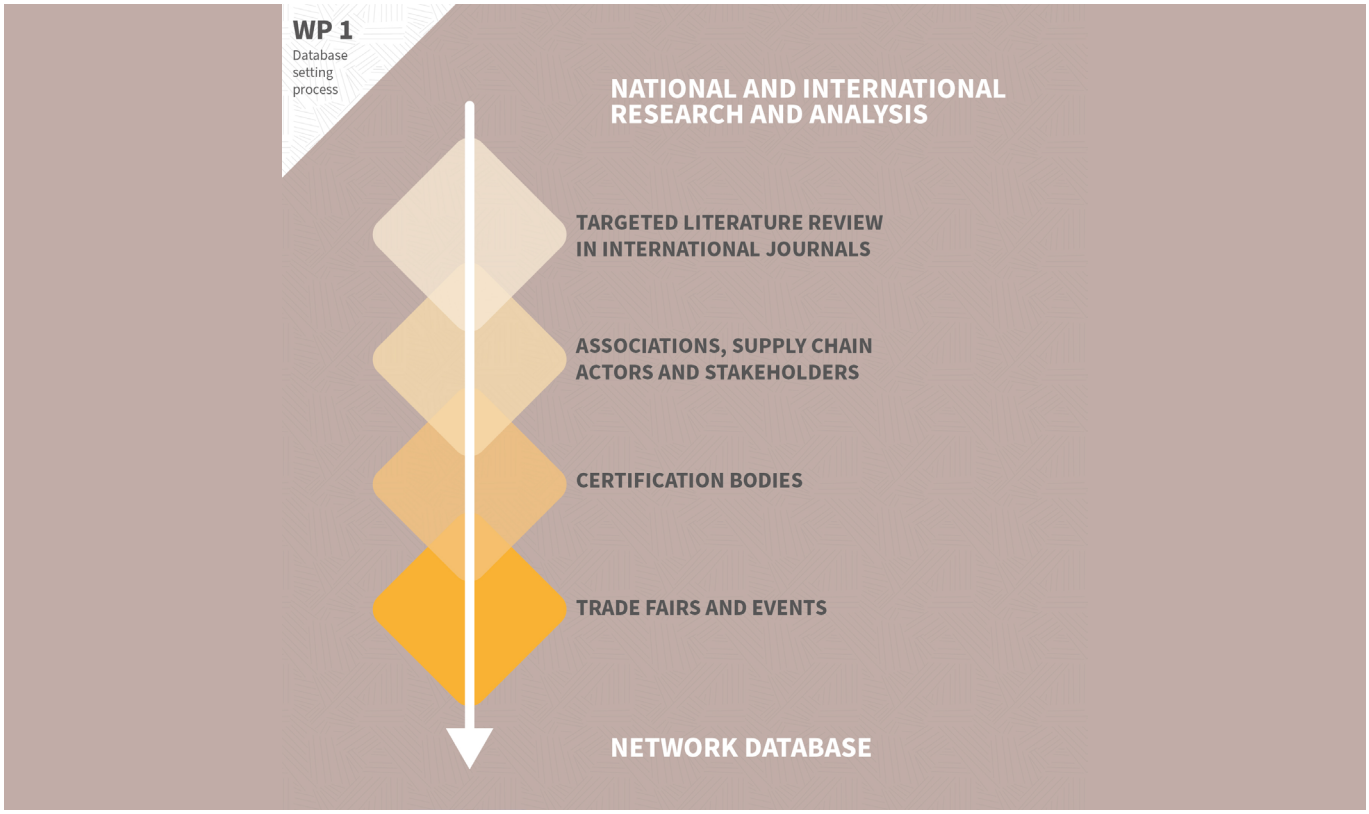

Fig. 03

tions, the framework examines the development of new market opportunities, improvements in resource utilization efficiency, and the creation of additional value streams through cross-sector applications.

Environmental performance monitoring utilizes both direct measurements and modelled impacts. Key metrics include reductions in waste generation, improvements in energy efficiency, water conservation, and the adoption of circular economy practices. The framework particularly emphasizes the tracking of improvements in wool washing processes and the development of local, environmentally sustainable processing capabilities.

Welfare indicators examine the broader community benefits arising from project initiatives. These measures assess improvements in local employment opportunities, enhancement of community resilience, and the strengthening of local economic networks. Particular attention is paid to the project contribution to maintaining viable rural livelihoods and supporting traditional wool-working communities.

THE FILA OBSERVATORY MODEL

The Observatory's digital platform will be a hub for stakeholder interaction and knowledge sharing. It will include a geo-referenced mapping system that will display resources and processing facilities in the main Italian regions for the wool supply chain, allowing for the continuous expansion of the database.

The collaborative nature of the platform will be manifested through spaces dedicated to stakeholder engagement, where industry participants will be able to share experiences, challenges and innovative solutions. In addition, an archive will showcase best practices and research results, making data-driven research information accessible to all participants.

The development of sustainable processing methods will be a strategic element of the project's implementation and value proposition. The project will support the creation of local operational clusters, strategically located to minimize transport impacts and maximize resource efficiency. Quality improvement protocols specifically designed for local wool varieties will help improve the market competitiveness of Italian wool, while preserving its

unique characteristics, both from a commercial and narrative point of view, and from a territorial and community promotion point of view.

The success of the Observatory depends heavily on effective stakeholder collaboration. Multi-stakeholder engagement protocols ensure balanced representation and participation from all sectors of the industry. The governance structure establishes clear decision-making processes while maintaining flexibility to adapt to changing industry needs. The possibility of taking on an advocacy and policy role on a specific supply chain issue could also be an important added value of the Observatory.

Regular knowledge-sharing events and training programmes promote continuous learning and skills development among participants. Cross-sectoral innovation initiatives, exchanges of EU founding researchers and academic and scientific meetings are part of the Observatory's work.

The FiLA Observatory represents a significant step toward helping the Italian wool industry through systematic innovation and sustainable practices. The project success depends on continuous stakeholder engagement and the ability to adapt to evolving market conditions and technological advances. Several critical challenges warrant ongoing attention. The long-term financial sustainability of the platform requires careful consideration of revenue models and value creation mechanisms. Maintaining consistent stakeholder commitment and participation demands continuous demonstration of tangible benefits and value creation. The regulatory landscape and market dynamics require constant monitoring and adaptive responses. The scaling of successful pilot initiatives presents both opportunities and challenges for broader industry transformation.

CONCLUSIONS AND OPEN PERSPECTIVES

By integrating circular economy principles with local development strategies, the FiLA Observatory project aims to contribute to a more sustainable and prosperous future for the sector. Through its approach to stakeholder engagement, sustainable process development and digital integration, it is intended that local development and circular economy principles provide a framework for implementing an integrated design strategy to add value to a material. The growing burden of disposal costs could catalyse initiatives aimed at transforming the perception of Italian wool from waste to valuable resource, underlining the urgency of a strategic response to increase the resilience and sustainability of the sector. Considering these challenges, the proposal to create a network within the Italian wool supply chain has emerged as a possible solution to foster collaboration, transparency and innovation among stakeholders. Furthermore, the current state of the Italian wool supply chain reflects broader concerns about sustainability and traceability, as consumers increasingly demand responsibly sourced materials. The establishment of an Observatory could not only improve transparency and traceability within the sector but also contribute to the adoption of more environmentally friendly practices, meeting consumer expectations and mitigating environmental impacts. While the potential benefits of a Network Observatory are significant, several challenges remain, including the need for rigorous data management and stakeholder engagement, which will also benefit farmers whose economic conditions are starting to make it impossible for them to continue the decreasing amount of farming work required throughout the supply chain.

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The contribution is the result of a common reflection of the authors. Nevertheless, the introductory paragraph (numbered as 1) and the paragraph 2 are attributed to Luciana Mastrolonardo. The paragraph 3, 4 and 5 are to be attributed to Rossana Gaddi.

CAPTIONS

[Fig. 01] Project Concept and Methodological framework of the value proposition of the FiLA Observatory (with expected results and specific outcomes): Graphical elaboration by the authors, 2024.

[Fig. 02] Methodologies for Data Analysis: Graphical elaboration by the authors, 2024.

[Fig. 03] Database Setting process: Graphical elaboration by the authors, 2024.

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