From plate to fabrics: harnessing food loss and waste for fashion and design applications

S. Micheletti, F. Chiriacò*, G. Burini, M. Pero, F. Ciccullo

** Dipartimento di Ingegneria gestionale, Politecnico di Milano, Via R. Lambruschini, 4 20156 – Milan – Italy*
(sara.micheletti@mail.polimi.it; franco.chiriaco@polimi.it; giorgio.burini@polimi.it; margherita.pero@polimi.it; federica.ciccullo@polimi.it)*

Abstract: Food loss and waste (FLW) are among the paramount sustainability challenges that modern society is currently facing. Along the food supply chain, resources are employed for creating food products that fit human consumption but they are often left to spoil and expire or they are scrapped during the production process. On the other hand, other industries, like fashion, are confronted with the unsustainability of specific raw materials, which have multiple negative environmental impacts in the extraction and processing phase and are connected with unsustainable practices also from a social point of view. Therefore, there is an interesting opportunity to discover new applications for FLW, making specific investments to create a zero-waste environment and designing the so-called "circular open loop supply chains". In this effort, young ventures or startups are core players that develop competencies related to the optimisation of resource utilisation from FLW and the creation of new, sustainable biomaterials for the fashion and design sector. This phenomenon is new and unknown, paving the way for a brand-new field of research. On these premises, this research develops six exploratory case studies on companies in the fashion, textile, or interior design industries, to investigate why and how companies in the fashion, textile or interior design industries develop circular supply chains leveraging FLW. The results of the study identify the role of FLW in different food industry segments and describe the context in which companies that use food loss and waste for fashion and design applications operate. Finally, this study elaborates a framework to address the practical aspect of how the existing fashion supply chain should change to welcome the utilization of food waste for fashion and design applications. This includes the identification of the relevant stakeholders, the relationship to be established, and the respective responsibilities.

Keywords: Food loss and waste valorisation, fashion and textile, circular supply chain, multiple case study.

1. Introduction

Every year 1.3 billion tons of food exits in the food supply chain as waste, covering all stages from agricultural production up to consumption (FAO, 2019). Food loss and waste (FLW) is an extremely relevant issue for modern society, representing economic losses for all actors along food supply chains, including consumers, highly inefficient use of resources (e.g. labour, water, energy and land), and impacting food security and nutrition (FAO, 2019). As a result, it is crucial to find innovative uses for scraps, making investments to create a zero-waste environment (Oliveira et al., 2021).

Additionally, the inputs raw materials used by the fashion and design industry cause a cascade of issues with sustainability (Jia et al., 2020; Papamichael et al., 2023). A recent research study focuses attention on the 'buy-and-throw-away' philosophy that joins together fashion, textile, and interior design (Papamichael et al., 2023).

To mitigate such issues, new businesses oriented toward FLW optimisation and valorisation and the creation of new sustainable biomaterials for the fashion and design sector are emerging as a novel trend. This phenomenon represents a blue ocean, facilitating the emergence of a brand-new field of research (Stenton et al., 2021b). Due to the limited knowledge concerning the use of FLW for fashion and design applications reported in current literature, it is important to further study such a topic (Provin et al., 2021). For this reason, this study addresses such a topic by further exploring the use of FLW as input raw material for the fashion textile, and interior design industry (FT&ID). First, it investigates the possible application areas where FLW can be employed. Second, it seeks to identify the additional stakeholders required to exploit FLW for fashion and design applications, as well as new relationships to be established with a traditional fashion supply chain. To accomplish these objectives, we formulated two research questions:

RQ1. What role may food loss and waste play in the fashion, textile, and interior design industry?

RQ2. Which are the main stakeholders companies that use food loss and waste in the fashion and design industry? And what are their relationships?

In trying to minimise the gap highlighted in this section, this study developed a framework showcasing the transition from a traditional FT&ID supply chain to a "circular open loop supply chain". It identifies the relevant stakeholders, the relationship to be established, and the respective responsibilities.

This article is organised as follows: Section 2 introduces the concepts and definitions, Section 3 the methodology

employed, Section 4 the main results used in Section 5 to formulate the framework, and Section 6 concludes the study.

2. Theoretical background

2.1. Food loss and waste

Current literature reports an inhomogeneity in defining FLW, resulting in different definitions. Moreover, in most cases, FLW are kept separated, referring to waste generated at the production level and waste generated at the consumption level (Lemaire & Limbourg, 2019). For this study, this discrimination is not needed and the authors refer to FLW as wastage in general defined as the "decrease in quantity or quality of food along the food supply chain" (FAO, 2019), from production to consumption. In any case, this food does not reach its intended purpose of nourishing people. This generates on one hand economic losses for upstream and downstream food supply chain actors, while on the other hand new revenue opportunities through their exploitation in other sectors, such as the FT&ID industries (Stenton et al., 2021b).

2.2. Fashion, textile and design industry and FLW

Fashion was defined by (Brun et al., 2008) as a "cross-sector concept" that encompasses several industries, such as apparel, footwear, leather, jewellery, and perfumes (Macchion et al., 2015). Fashion supply chain encompasses several processes from fibre and yarn manufacturing, spinning weaving, bleaching, finishing, to end garment manufacturing with cutting and sewing, and lastly, distribute and sell the final products (Franco, 2017). These processes are carried out by different supply chain actors, which comprehend yarn supplier, fabric supplier, garment manufacturer and brand owner and retailer (Burini et al., 2023). Within this context, FLW can be used to make garments, clothes, and leather items such as shoes or bags, as well as compostable materials. Moreover, it can be expanded to the production of furniture items, as well as car parts. Current literature already started to investigate the use of FLW in this industry. Scientific studies focus on the use of FLW to perform wastewater treatment (Al-Zawahreh et al., 2022; Nekvapil et al., 2023; Pham et al., 2023). Current literature also reports a strong attention to the employment of FLW as a primary resource (Auerbach George et al., 2022; Stenton et al., 2021a; Lahiri et al., 2023). Moreover, different contributions focus on the use of FLW as raw material essential for the production of a growth medium for microorganism cultivation (Mishra et al., 2023; Svensson et al., 2022; Soh et al., 2021). FLW can be also used as a natural dye for textile tinting and as a reducing agent to improve garment performance (Papamichael et al., 2023; Xia et al., 2023). Lastly, Provin et al. (2021) reviewed the literature to exploit FLW as a linking point between the food and textile industries. Moreover, when exploiting innovative raw materials new stakeholders emerge. Indeed, in addition to supply chain actors previously introduced, knowledge stakeholders and other external stakeholders are identified (Herczeg et al., 2018). The author defined knowledge stakeholders as private or public research institutions typically in charge of developing new materials, products, and processes and which bring extra knowledge to firms. In this group are also considered organizations that handle logistics, transportation, and supply chain management in general. Instead, external stakeholders are organizations like the government, regulating bodies, and eventually environmental groups, which set rules, regulations and practices. (Herczeg et al., 2018).

2.3. Circular open loop supply chains

In circular supply chains, two types of resource flows exist: "Primary resource flows" and "Circular resource flows". The former refers to the circulation of primary goods within a business, while the latter emphasizes the closed-loop management of resources like raw materials and energy through techniques such as recycling, reuse, and product life extension (Farooque et al., 2019). Recently, open-loop flows emerged as an extension of closed-loop flows in extending value creation beyond a single supply chain (Ciccullo et al., 2023). Managing these flows requires different strategies and fosters the need for strong collaborative relationships among all participants in the extended supply chain (Sudusinghe & Seuring, 2022). In particular, literature emphasises the need for sharing information, risks and resources within supply chain collaborations, which are shifting into more horizontal collaborations, including new actors such as startups, research institutes, government, NGOs (Ciccullo et al., 2023; Sudusinghe & Seuring, 2022).

3. Methodology

The novelty of this research sustained the choice of the case study method (Yin, 2009). We resorted to exploratory multiple case studies. The explorative nature is justified by the uncertainty of the major feature of the case and the need to select cases based on the possibility of studying a certain phenomenon (Yin, 2009). The multiple nature is justified by selecting different companies exploiting FLW for the FT&ID industries (multiple nature). The study selected six companies from FT&ID industries using FLW to produce yarn, organic leather, or design products. They are either start-ups, sections of larger manufacturing units focusing on sustainability, or even manufacturing companies with a department dedicated to the production of FLW materials. Due to the limited number of companies suitable for this research, no location restrictions were considered. Appendix A reports more detailed information about the interviewees and the companies considered. Data collection employed different sources of evidence. Information was gathered through semi-structured interviews, followed by data triangulation from official websites and social media to complete missing information, add new sources of data and obtain a more comprehensive understanding of the case study (Eisenhardt, 1989; Gioia et

al., 2013). The interviews were conducted online using either Zoom or Google Meet and lasted 30 to 45 minutes. With the consent of the participants, all interviews were audio-recorded for later analysis. The research employs abductive coding following established guidelines (Gioia et al., 2013). First, data was summarised in a structured database. Then, two coding cycles were conducted. The initial cycle helps describe each case study. The second cycle focuses on categorization, where first-order codes are grouped into higher-order themes that integrate theoretical variables, i.e., final product, stakeholders and relationships. This stage involves a thorough examination of patterns identified in the first cycle, leading to the classification of emerging similarities and differences.

4. Results

A cross-case analysis was conducted, identifying similarities and differences among the cases.

4.1. Food waste and final product

Companies A and C are two realities working with different types of FLW with adaptable production processes. Their final products can be categorised as a bio-composite in which FLW plays the role of primary resource. Indeed, the final product in these case studies is made up of more than 50% locally sourced FLW. Similarly, Company B has the same final product, but the start-up chose to rely only on one source of FLW. This choice made it less adaptable to handling different types of waste, but more standardised in the production process and able to cope with potential difficulties in FLW collection. Furthermore, Company B can produce the most visually appealing products, but at a much slower rate compared to Companies A and C.

Companies D and E only use coffee grounds as a source of FLW to produce and sell different final products. Apart from the single type of FLW used, these two companies use FLW as filler in their production. Contrary to the exploitation of FLW in the previous three cases, here FLW constitutes less than 50% of the final product. Another similarity between Company D and E is the number of final product types produced; both chose to differentiate their output between three types of materials with similar characteristics and small differences. The main distinction lies in the enhanced performance of Company E's finished garments, which can significantly impact the marketing of the final product.

Company F can handle different types of FLW thanks to the established relationships with different start-ups with FLW knowledge. They are supplied with similar already treated FLW, thanks to which they can adapt their production process and always obtain the same final product. The synthetic leather sold in the fashion industry is made with less than 50% of FLW, for this reason, the FLW role for the case of company F is categorised as a filler.

Drawing upon results presented in the previous paragraphs Table 1 lists all the FLW sources employed and links them to each company, while Table 2 details the final products resulting from the use of FLW materials.

Table 1: Food waste used in the case studies.

FLW source	Firm ID	FLW source	Firm ID
Coffee grounds	A, D, E	Kombucha leaves	C
Agri waste	A, C, F	Grape waste	C
Tea leaves	A, C	Apple waste	F
Citrus peel	A, C	Olive waste	B
Other fruit peels	A	Beer waste	F

Table 2: Final product manufactured by case studies.

Final product	FLW role	Firm ID
Bio-composite	Primary resource: FLW>50%	A, B, C
Bioplastic granule PLA, LDPE, HDPE	Filler: FLW<50%	D
Biomaterial –Yarn, Foam, Membrane	Filler: FLW<50%	E
Functional printing	Primary resource: FLW>50%	E
Biomaterial – Leather	Filler: FLW<50%	F

4.2. Stakeholders

Relevant stakeholders considered were identified for each company, i.e., the suppliers of FLW, the buyers of final products produced with FLW sources, the distributors of final products, the additional business partners involved, the knowledge stakeholders, which bring extra knowledge to firms, and finally, the external stakeholders, which set rules, regulations and practices (Herczeg et al., 2018).

Suppliers of FLW identified during the analysis of the case studies are of different types. First, there is the Local Food Industry (LFI), which comprehends both production firms and farmers. Following, there is the Local Hospitality (LH), which includes restaurants, hotels, coffee, and tea shops. Additionally, also External Food Industry (EFI) suppliers and Local Supermarket (LSM) are present. Lastly, there can be also Local Individuals (LI), i.e., people who contribute to the collection of FLW near the production site. Among the actors identified as FLW suppliers, some of them are also buyers of the final products such as LH, LI and LFI.

The most common buyers identified from the six case studies come from the FT&ID industry, the reference industry. First, there is the Local Reference Industry (LRI), which includes companies and brands belonging to the fashion, design, furniture and textile sectors. In addition, External Reference Industry (ERI) buyers are also present to the same extent as LH and some other actors such as banks and offices, which are categorised as Local Other Companies (LOC). People from the same country of the companies (LI) or from other

countries and continents, namely External Individuals (EI), are buyers of the final product made from FLW.

Distributors are actors responsible for the final product transportation. Company A is the only one that does it all by itself, relying on its internal resources and public distribution facilities. Companies B, C, D and E resort to an external distributor, which is necessary due to the location of the business unit. Finally, Company F, being a manufacturing company that collaborates with FLW start-ups to produce final products from FLW, has the FLW start-up itself as its primary distributor for this type of item.

Concerning business partners, no additional actors were identified for companies A and B. Contrary, Company C has an international retail partnership, while Company E exploits the knowledge of a scientific and biotechnological research institute. The business partnerships of Company D and Company F are closely correlated, Company D relies on a manufacturing plant (MP) to produce the final product, while Company F exploits the knowledge acquired from FLW start-ups in the interaction with its supplier. Finally, Company B and Company D both have a physical shop, respectively in another country and linked to fair trade retailing.

Considering knowledge stakeholders, Companies B, C, D and F established and/or planned relationships with local universities (LU) to share information about processes, materials and markets. Contrary, Companies A and E did not mention anything about LU. It is worth noting Company E, in business for more than 10 years, has an internal R&D department. Moreover, Companies A, B, and C all leverage a freelance workforce, including designers and photographers (D&P). Company D is planning to establish a partnership with a logistics and transport service provider to support its business. Finally, Company A also relies on a sales agent (SA) to manage its sales.

External stakeholders were only mentioned in case C, where the company resorted to government incentives to finance its business, especially during the initial phase of the FLW star-up development.

4.3. Relationships among Stakeholders

Standard agreement procedures are identified between companies A, D, E and the respective buyers and suppliers. Contrary, companies B and C only have standard procedures for the relationships with suppliers. Lastly, Company E possesses a standard procedure with the FLW start-ups.

Contracts between both suppliers and buyers with companies D and E are identified. Company A only signs contracts with buyers, company B only with suppliers and company E only with FLW start-ups.

An equal bidirectional information exchange concerning materials and design between knowledge actors and companies B and C is present. Unidirectional information sharing on FLW between FLW start-ups and their suppliers and buyers is identified. From cases D and F, it was identified a bidirectional knowledge sharing about FLW processing and final product production between FLW start-ups and manufacturing companies.

In terms of risk sharing, the risk is mainly on the shoulders of FLW start-ups. This is unidirectional or slightly bi-directional between start-ups and suppliers, buyers and knowledge stakeholders. Contrary, the analysis suggests that when the government is involved in providing incentives, the investment risk falls entirely on this external stakeholder, as highlighted in case C.

All the companies are adaptable and capable of adjusting the final product and design during the production process. Companies A and C have a high degree of flexibility and adaptability thanks to their manual and slightly automated processing, whereas company B has more standardised products and production, resulting to be less adaptable to product and design modifications. Having an internal proprietary process, Companies E and F are highly capable of making design and product modifications during production, having full control and knowledge about the manufacturing. Contrary, Company D has a low ability to control and perform product modification during production due to the decision to outsource the production process to manufacturing plants.

When it comes to relationship building, trust between stakeholders is recognised as essential. In all case studies, an Identification Based Trust (IBT) relationship (Ramsheva et al., 2019), where partners internalise each other desires and intentions, is always identified, except for company F. Companies A, B and D have in common the recognition of the importance of a friendship-based relationship in the early stages of business development, which characterises these FLW start-ups. This feature was not mentioned by companies C and E. Moreover, companies D and E also adopt a Knowledge Based Trust (KBT) approach (Ramsheva et al., 2019), which is more focused on predicting the other's behaviour through a deeper analysis during the relationship-building process.

5. Discussion

5.1. The role of food waste

The role of FLW in companies using it on the market for fashion and design purposes is categorised and compared with current literature concerning the role of FLW in the studied industry. The results showcases a wide application of FLW on the market as a primary resource or filler. These categories differ based on the amount of food waste used. Companies in the first category use food waste as their primary resource (FLW > 50%), while those in the second use it sparingly (FLW < 50%). In addition, a not negligible number of companies employ FLW for the growth of microorganisms that produce natural filaments or leathers that can be employed for fashion and design applications.

5.2. Open loop fashion circular supply chain mapping

Appendix B displays how the existing fashion and textile supply chain changes to welcome the utilization of food waste for fashion and design applications, by comparing the two different supply chains. The traditional activities within the fashion supply chain remain intact, but they are now complemented by an additional activity: the "supply of food waste", along with the associated actors. Three types

of links that specify transfers and flows among actors are present. A continuous line is used to display material flows; a segmented black line is used to highlight the information and knowledge flows among actors; lastly, a discontinuous line made by pink dots is used to represent the government incentives flow. Before describing the framework, it is important to address the presence of different actors represented in the framework:

- Orange actors: represent Food Loss and Waste (FLW) suppliers and Final Product (FP) buyers.
- Blue actors: represent the Knowledge Stakeholders (KSH) involved in the activities and necessary to perform the task.
- Green actors: represent a new entity called Connector, which acts as a link between different stakeholders facilitating the flow of information and knowledge. The Connector establishes and maintains relationships among stakeholders. If possible, this role should be assigned to a specific person inside the start-up, avoiding roles overlapping.
- Pink actor: represents the only external stakeholder involved, the government, which is particularly relevant at the beginning of the activities. Its incentives are essential to "Supply of food waste".
- Red actor: represents the stakeholder in charge of the management of FLW and final product material flows. It looks after all logistic and transportation aspects, and it is essential when a lot of suppliers of FLW are present, and the buyers' network expands.

Appendix B showcases the importance of "Supply of food waste" as a new activity. This necessitates the involvement of new participants beyond those currently involved in the traditional fashion supply chain. The process starts with a "Connector for FLW supplier" identifying FLW as a potential raw material. They then contact a "FLW supplier" to acquire the "Food waste". In addition, the "Connector for FLW supplier" keeps a knowledge exchange flow with a knowledge stakeholder for the acquisition of the know-how that regards FLW storage, namely "KSH for FLW storage", and communicates the information gathered to the "FLW supplier" when necessary. The same procedure is adopted by the "Connector for FLW supplier" concerning the "Logistic and transport partner". The latter manages FLW transportation for the "FLW suppliers", arranging depot places and establishing a strategy for the FLW collection. Lastly, incentives from the government are present, towards both "Connector for FLW supplier" and "FLW suppliers", to encourage the donation of FLW, limiting the money transaction for FLW acquisition, which can require more effort, agreements, contracts, and risks between the actors involved. Overseeing all these aspects, the "Connector for FLW supplier" is the ideal actor capable of taking responsibility for establishing relationships with "FLW suppliers", while establishing and maintaining relationships with other stakeholders such as "Government", "KSH for FLW storage" and "Logistics and transport partner".

When the "Supply of food waste" activity is completed, the new sourced raw material "Food waste" is ready to be introduced, along with other materials, into the "Make" phase that will lead to the final product being manufactured. The production starts with the "Projects statement and design" activity, which is the first step before the actual processing phases. When introducing FLW among the raw materials, several new actors are involved to successfully perform this task. A "Connector for FLW project and design" keeps track of information and knowledge flows among several actors and communicates with the project manager. Firstly, "KSH for FLW role selection" are essential to choose the right role of FLW among different possibilities. A Biotechnology and science research institute or a LU can cope with this task, pointing out if the FLW collected can be employed in the first processing activity ("Processing 1") as a filler (FLW < 50%), a primary raw material (FLW > 50%), or growth medium for microorganism, or in the second processing activity ("Processing 2") as a natural dye, reducing agent or material for functional printing. Secondly, "KSH for FLW design" are needed to be able to project the most appropriate and appealing item with the FLW selected and used in one of the just discussed ways. Overseeing all these aspects, the "Connector for FLW project and design" is the ideal actor for establishing and maintaining relationships with "KSH for FLW role selection" and "KSH for FLW design". Thirdly, the "Connector for FLW project and design" communicates to the "Connector for FLW processing", which shares information with the manufacturer responsible for the "Processing 1", "Processing 2" and "Processing 3" activities. Successful completion of such activities requires constant knowledge exchange between the "Connector for FLW processing" and "KSH for FLW processing requirements". The KSH team understands the need for pre-processing FLW, and potential manufacturing issues with specific waste types, and can adjust machines and dwell times based on processing results communicated by the Connector. It is noteworthy that when "KSH for FLW processing requirements" and "KSH for FLW role selection" actors belong to the same category of KSH, such as those working at the same local university or biotechnology and science research institute, the information and knowledge flows between them are clearer and more straightforward, reducing the likelihood of communication misunderstandings. Overseeing all these aspects, the "Connector for FLW processing" is the ideal actor that can establish and upkeep relationships with "KSH for FLW processing requirements".

Lastly, "Connector for FLW processing" must be in contact with "Connector for FP buyer" and with "Connector for FLW project and design" to consider also the final product requirements of the brand which wants to include FLW. These requirements must be considered both during the activity of "Project statement and design" and after its closure, when "Processing 1, 2 and 3" begins, leading to a fully flexible openness to product and design adjustments. To successfully perform "Make" activities, a constant bidirectional information flow should be maintained among the three Connectors, splitting the responsibility among three different people in the start-up, where possible.

Moving to the "Delivery" phase, the activity "Sales of final product" can still be conducted traditionally, delivering the end manufactured items to the "FP buyers". However, when introducing FLW, new buyers occur, such as LRI and ERI, which include companies and brands connected with fashion, textile, furniture, and design, are the main buyers. Moreover, there are also buyers from LH, such as coffee shops and restaurants, and LOC such as banks and offices. Lastly, the sales expand also to local or from other countries individuals. Having such a variety of buyers and being some of them also part of the "FLW suppliers", the need to shift part of the sales of FP towards the actor "Connector for FP buyer" is evident. In addition, this Connector can share information with "Logistic and transport partner" and go back to "FLW suppliers" with the final product manufactured with their FLW. Overseeing all these aspects, the "Connector for FP buyer" is the ideal actor for establishing and upkeeping relationships with "FP buyers" and upkeeping them with "FLW suppliers".

Finally, a consideration of the "Use phase" is provided. Food waste-derived goods have peculiar characteristics that need to be made evident to consumers. These include shelf life, biodegradability and compostability, and product care requirements. The "Connector for FP user" is the ideal actor to take on the duty of establishing and maintaining relationships with customers, it gets information about the final product's properties in a unidirectional manner from the "Connector for FP buyer" and relays it to the customers.

Table 3 showcases the Connector responsible for establishing relationships with specific actors in the new supply chain.

Table 3: Connector stakeholder role.

Connector	Relationship establishment
Connector for FLW supplier	FLW suppliers, Government, KSH for FLW storage, Logistic and transport partner
Connector for FLW project and design	KSH for FLW role selection, KSH for FLW design
Connector for FLW processing	KSH for FLW processing requirements, Manufacturing plants
Connector for FP buyer	FP buyers and FLW suppliers
Connector for FP user	Final customers

6. Conclusions

This study has underscored the pivotal role of FLW in creating a more sustainable FT&ID industry. By repurposing FLW as alternative raw materials, the FT&ID industry can establish an open-loop circular supply chain, thereby enhancing circularity and sustainability. Furthermore, the research has elucidated the critical relationships and stakeholders required to establish such an open-loop circular supply chain. In this context, knowledge, information, and risk sharing emerge as fundamental factors, alongside the cultivation of trust among partners. Additionally, the study emphasises the importance of the 'connector' role, adding empirical evidence to enrich the existing literature on orchestration. As a result, this study extends the current literature on the use of FLW as input raw material for the FT&ID industry by presenting a framework which showcases the changes needed to welcome FLW.

Concerning practical implications, this study helps fashion and design companies and food waste start-ups to properly manage the introduction of food loos and waste in the FLW, fashion and design supply chain. In pursuing this purpose, this study set the basis for the establishment of the relationship with all stakeholders necessary to keep up with the massive amounts of knowledge, information and material flows. Through the employment of the framework presented in this study, the practical aspect of how the traditional fashion supply chain should change to embrace the adoption of food waste for fashion and design applications is addressed. The traditional fashion supply chain activities are maintained but they are integrated with one additional activity, the "Supply of food waste", and the actors related to it. The "Supply of food waste" leads to the procurement of new raw material called "Food waste", it requires the involvement of new actors with respect to the traditional supply chain.

This study also has some limitations on which researchers can leverage for future research. First of all, qualitative research is vulnerable to human biases, leading to loss of details and excessive personal interpretation. Despite the value of providing a description of the network of relevant stakeholders, the relationships in place and the relevant transactions in open loop circular supply chains, further researches are needed to find recurring patterns with associated drivers, which can guide future open loop circular supply chain design.

Moreover, other cases can be conducted to enrich the presented framework. New start-ups constantly emerge to provide companies with innovation to support their businesses. Furthermore, this research can be integrated with a detailed analysis of the present agreements that characterise the relationship establishment between stakeholders that deal with food waste for fashion and design applications, this includes highlighting what type of standard procedures and contracts are present, in line with also an investigation on how the risk is shared among actors. Future research should focus on food loss waste used as growth media or natural dye. Further research should explore the characteristics of materials correlated with food waste for fashion and design applications, focusing on end-of-life processing requirements, biodegradability, compostability, water resistance, and weather influence. While addressing the technical properties that characterise these materials, a full LCA of food waste-based materials is also proposed for future research.

Acknowledgments

This study was carried out within the MICS (Made in Italy – Circular and Sustainable) Extended Partnership and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E

RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.3 – D.D. 1551.11-10-2022, PE00000004). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them

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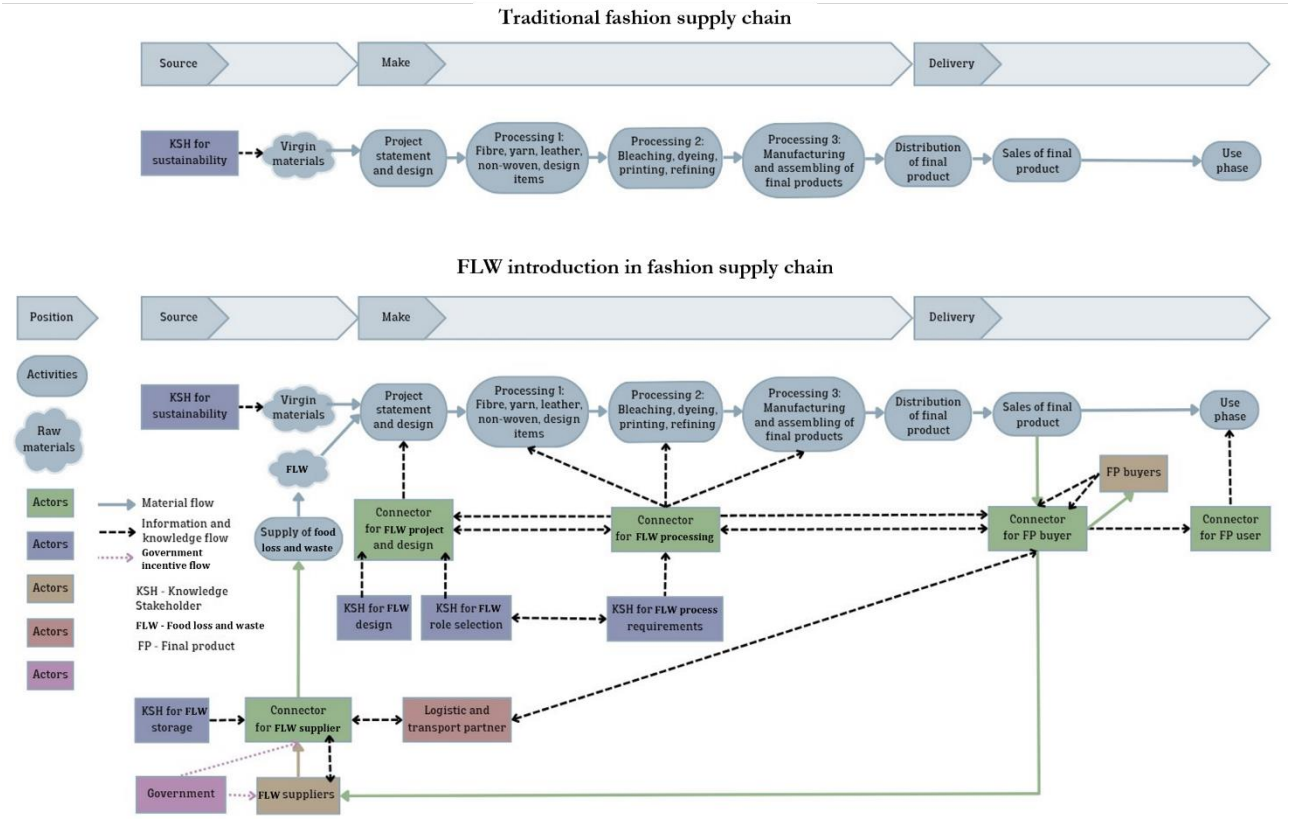
Appendix A. COMPANY INFORMATION

Firm ID	Industry	Type	Lifetime	Location	Interviewee
A	Design	Start-up	1 year	Turkey	Chief Executive Officer
B	Design	Start-up	3 years	Greece	Production and design specialist Market and communication strategist
C	Design	Start-up	4 years	Finland	Chief Executive Officer
D	Design	Start-up	1 year	Italy	Chief Executive Officer
E	Fashion Textile	FT company's section	14 years	Taiwan	Senior Global Sustainability Manager
F	Fashion Textile	FT manufacturing company	13 years	Italy	Business development manager



Appendix B. OPEN LOOP FASHION CIRCULAR SUPPLY CHAIN MAPPING