

ENVIRONMENTAL DESIGN

4th International Conference on Environmental Design

9-11 May 2024

*A cura di
Mario Bisson*

ENVIRONMENTAL DESIGN

Conference proceedings of the
4th International Conference on Environmental Design

Environmental Design : IVth International Conference on Environmental Design
A cura di Mario Bisson

Proceedings (reviewed papers) of the IVth International Conference on Environmental Design,
Mediterranean Design Association | www.mda.center | info@mda.center
9-11 May 2024, Ginosa, Italy

Progetto grafico ed impaginazione: Federico De Luca e Giulia Alvarez
Immagine di copertina: Federico De Luca
ISBN 978-88-5509-634-8
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Palermo University Press | Finito di stampare nel mese di Maggio 2024

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Introduction

by Mario Bisson

"Everyone engaged in devising courses of action aimed at transforming current situations into more desirable ones is essentially involved in design. Whether in fields such as engineering, medicine, business, architecture, or painting, the focus is not merely on what is necessary but on what is possible. These disciplines concern themselves with envisioning alternative futures, exploring potentialities rather than accepting things as they are. In essence, they are concerned with design."

- Herbert Alexander Simon

Progress necessitates a proactive approach, one that involves researching and understanding our environment with a view toward shaping future outcomes. We often find ourselves immersed in discussions about environmental issues such as pollution, traffic, and consumption, yet active participation is not always as prevalent.

The Environmental Design Conference serves as a platform for shedding light on the outcomes of research efforts across various fronts. It fosters scientific discourse among researchers, making visible both theoretical frameworks and empirical evidence. Moreover, it aims to raise awareness among public institutions and businesses about the necessary steps for a sustainable future, ultimately enhancing personal well-being and community welfare.

Engaging in discussion, analysis, and proposal is imperative in navigating the challenges that lie ahead. By inviting scientific luminaries from diverse backgrounds and distinguished research institutions, the conference facilitates the exchange of ideas, fostering innovation and driving progress. It provides an invaluable opportunity for emerging scholars to showcase their research on an international stage, fostering collaboration and enriching the collective vision of the MDA community, dedicated to enhancing the quality of life.

MDA periodically hosts conferences open to researchers worldwide who share an interest in contributing to the ongoing dialogue on improving quality of life. The 2024 Conference held in Ginosa saw participation from researchers from different disciplines. The outcomes of this event have been documented in a volume accessible on the association's website (mda.center), serving as a testament to the collective efforts toward a better future.

Fashioning a Sustainable Future: Navigating Zero-Waste Practices in Textile Chain

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Keywords:
Zero-Waste Design
Pre-Consumer Textile Waste
Fashion Industry
Literature Review

Abstract

This research highlights the significant issue of textile waste generation in Europe, with over 15 kilograms per person annually, making the clothing and textile industry highly resource-intensive and waste-generating. In Italy alone, 480,000 tons of textile waste were produced in 2019, originating mainly from the textile industry and urban waste sorting. While some efforts were made to recover materials from this waste, a considerable portion still ended up in disposal or intermediate activities. The research, part of a national project funded by the NextGeneration EU program, aims to analyse the textile sector's strategic importance and advocate for more sustainable and circular approaches. It explores the implementation of zero-waste design principles in fashion through a literature review, emphasising the role of design decisions in the entire garment lifecycle and the potential for textile scrap to drive innovation and socio-economic benefits in the industry.

Introduction

Today, more than 15 kilograms of textile waste is generated per person every year in Europe (McKinsey, 2022) and the clothing and textile industry is considered a highly resource-intensive and waste generating industry (Bonifazi et al., 2022). According to the report "Italy of recycling" (2022), the Foundation sustainable development and Unicircular, in 2019 Italy produced 480,000 tons of textile waste. 50% of these come from the textile industry, 30% from urban waste sorting, and the remaining 20% from other types of activity. As stated in the report, in 2019 46% of the waste in the textile sector was started to recover material, while 11% was destined for disposal. A very large share of waste, about 43%, was allocated to intermediate activities, such as pretreatment and storage.

This research is part of the national research project "Re-Waste. Circular Ecosystems in Textile Chain", ongoing at University of Florence, founded by NextGeneration EU programme whose aim to analyse the strategic sector of made in Italy, as the textile sector, in which it could find remarkable critical points that underline the negative aspects of linear model and its unsustainable nature (Di Giacomo, 2013). At the same time, this model shows the urgent need to change practices towards more sustainable and circular approaches and methodologies. The contribution wants to explore the implementation of zero-waste design principles in the fashion field (ElShish-

tawy et al., 2022; McQuillan, 2011; Rissanen & McQuillan, 2016; Rissanen, 2014, 2013) through an in-depth literature review, with a specific focus on the pre-consumer stages of the textile supply chain and their poetics (Binotto & Payne, 2017).

The review synthesises a comprehensive analysis of the various approaches and tools used in the fashion field and how they are employed by various stakeholders to address and manage textile waste having to do with the reduction, the recycle and the reuse of this materials, and also the use of processes that can be able to extend the life of the products and ameliorate the end-of-life process (Bonifazi et al., 2022; Di Giacomo, 2013). Highlighting the attention on the importance of adopt circular economic model, the opportunity that this model offers to the companies (Bastos et al., 2021; Gazzola et al., 2020), and the social role of designers, it underlines how design decisions impact the entire life cycle of garments. Moreover, the collection of textile scrap represents a great resource (deadstock and leftovers) that could support innovation in the textile field with a virtuous action able to elicit an enhancement in the economics and social area (Vaccari & Cerulli, 2014).

Methodology

The text aims to present the results of an initial literary analysis conducted between January and December 2023. Throughout the investigative phase of academic literature, the research expanded to encompass themes related to the social role of the fashion designer and the tools and approaches that can be employed in the prevention and management of textile waste, as well as in the production of new value from recovered materials. The research commenced by employing selected keywords pertinent to the theme of circularity and textile waste. The analysed texts were identified based on a series of keywords considered relevant to the ongoing research. Furthermore, the keywords were selected because they were deemed effective in obtaining a comprehensive overview within the context of sustainability and circularity regarding pre-consumer waste in the textile and fashion sector, with a focus on the potential to generate added value through the reintroduction of these products into the supply chain. Among the criteria for selecting the examined contributions is also the publication date: the selected texts span a period from 2014 to 2023, with a few exceptions that were included in the research due to their relevance to the topic or because more recent texts on the subject could not be identified.

The research was conducted through desk analysis of useful databases (e.g., the university's library catalogue and Google Scholar) to search for books, journals and articles. This process was undertaken subsequent to the creation of a list of keywords related to the research question, including all newly discovered keywords during the literature search. The identified keywords include: supply chain, textile supply chain, zero-waste, circular economy, textile and garment end-of-life, Prato textile district, zero-waste textile, sustainability in fashion, the poetics of waste in fashion, repurposing in fashion design practice, zero waste supply chain in Italy, recycling, textile mapping in Italy, regenerative fashion, digital transformation, fashion transition, community, and environmental sustainability. The employed keywords in the research underscore the intention to investigate the Italian situation regarding the pre-consumer supply chain and the desire to identify a new cultural and economic framework for textile by-products that are still considered unrecoverable—and devoid of value—by a significant portion of Italian production entities [1].

The production of waste materials and the end-of-life issue

In the academic realm, research highlights the interest of numerous authors in analysing the primary factors influencing the production of waste materials. As emphasised by Rissanen & McQuillan (2016), there are two broad categories of textile waste: waste generated by industry (pre-consumer textile waste) and waste generated by consumers (post-consumer textile waste).

The life cycle of textile products (i.e., fabrics and clothing) generates numerous environmental impacts so much that textiles were identified as a “priority product category for the circular economy” by the European Commission in 2019 [2], encourage technologies for textile waste recovery and recycling—the most effective methods for textile waste disposal due to their lower environmental impact even currently less than 1% of textiles are recycled globally, with rates around 25% in Europe and 16.2% in the US (Bonifazi et al., 2022), and obliging member states to separate these materials as of January 1, 2025 [3].

Textile waste as unused and/or unsold fabrics could represent a significant resource for fashion students as “put back on the market goods destined for disposal and thus create a virtuous action capable of generating improvement both from an economic and social point of view” (Vaccari & Cerulli, 2014). Authors highlight a significant issue within unused fabrics redirected to stockist market loss origin traces, disrupting “textile biography” data and lifecycle tracking and, in the case of branded fabrics or products produced under exclusive agreements these products face destruction due to copyright. Moreover, the European Commission’s call to reduce the use of natural resources to improve energy efficiency, Di Giacomo (2013) points out that the EU hosts approximately 50% of the industries worldwide that work starting from waste. The fashion production system [4], precarious and unsustainable in its linear model, is opening up to new opportunities that can arise from the view of waste as a solution to develop new economic activities.

Circular Economy and the Benefits for Businesses

Circular Economy (EC) is an economic model aimed at minimising waste and making the most of resources by reusing, recycling, and regenerating products and materials. Some authors report upon existing frameworks and methodologies for assessing circular economy initiatives providing a basis for policy-making of Italian regional levels (Bastos et al., 2021). Others analyse new trends in the fashion industry, focusing on the importance of the circular economy (Gazzola et al., 2020) underlines the need for companies within this sector to understand the opportunities offered by the circular economy. Italian Circular Economy Atlas is a web-based platform that documents the experiences of economic and associative entities applying circular economy principles in Italy since 2017. Pezzoli and Vaghi (2019) describe the criteria for evaluating circularity and environmental and social sustainability of circular initiatives, insights into the development and implementation of the Italian Circular Economy Atlas to confirm the importance of integrating sustainability principles into circular initiatives.

To understand cross-country differences in the sustainability performances of the manufacturing and service sectors, Mazzanti and Nicolli (2012) investigate the relationship between sustainability and innovative dynamics,

focusing on the role of firms, particularly public utilities, in environmental innovation. Combining quantitative and qualitative methods, it shows how environmental regulations can drive innovation for both economic and environmental gains, emphasising firms, including public utilities, as producers of mixed public goods.

According to Salvi et al. (2021), circular cities as case study of Prato, characterised by inclusive governance and innovative policies, can serve as models for sustainable urban development as represent a new approach to public life that emphasises the environment as a central actor, highlights the importance of collective action and addressing environmental and social challenges through collaborative approaches.

Providing a comprehensive analysis of Circular Economy (CE) adoption challenges and responses in the textile and fashion industries, Saccani et al. (2023) addresses the challenges hindering the transition towards a CE in industries with significant environmental impacts. Authors proposing a circular supply chain framework to address challenges within a case study conducted in the Prato regenerated wool district to emphasise the importance of adopting a systemic approach to overcome barriers effectively.

Fashion Industry 4.0

Investigating the themes of pre- and post-consumer waste in the Italian textile fashion sector also entails analysing the primary factors influencing the production of waste materials through a comprehensive understanding of production processes and supply chain mechanisms. In their study, Pratt et al. (2012) address the need to understand the fashion industry not only as a form of personal and cultural expression but also as a complex economic sector where to explore the parameters of the fashion industry and its implications for urban and regional economies, particularly in Europe. Federico Visconti, in the introduction to the book "Innovation and Sustainability in the Textile Industry" (2017, p. 9), draws attention to the industrial and economic dimension of the textile-fashion sector in Italy, emphasising the importance of manufacturing as the "beating heart of the Italian economy." The textile-clothing supply chain is a foundational sector of Italian manufacturing (p.9) with several industrial districts and their ancient history characterised by productive excellences, technological innovations, and a culture of craftsmanship that has developed strong innovative capacity that could experience a revitalization through sustainability initiatives, including the production of recycled and bio-based materials and fostering the whole supply chain. The sustainable fashion movement aimed to promote change in this industry, often with the risk of being simple greenwashing and social-washing, have raised an increasingly responsible attitude that is spreading on the part of the companies themselves and consumers who influence the market with their purchasing choices (Giorgianni, 2022).

The environmental impacts of products

When discussing sustainability, it is imperative to focus on those processes of Life Cycle Assessment (LCA), a methodology used to assess the environmental impacts of products, services, and systems throughout their entire life cycle (Scalbi, 2012), and material recovery for the production of secondary raw materials obtained from recycling materials external to the textile supply chain. These types of processes, as highlighted by Magni and Noè (2017), should be considered as a solution to achieve a reduction in energy consumption in the production of new materials, as well as the down-

sizing of unsustainable volumes of plastic waste (as in the case of PET).

Academic literature addresses the need for suitable assessment tools to improve the sustainability performance of products, services, and processes for assessing the environmental impacts of products, encompassing all stages from raw material extraction to end-of-life disposal, and on evaluating the social impacts of products throughout their life cycle in evaluating the environmental and social impacts of textile products. According to this theory, Lenzo et al. (2018), suggest to combine the approaches of Life Cycle Assessment (LCA) and Social Life Cycle Assessment (S-LCA), focus on conducting the first LCA and S-LCA on an Italian-made wool/cashmere garment to assess the social and environmental impacts associated with the garment's production [7].

The challenge faced by textile and clothing companies in translating sustainability commitments into action due to various factors such as a lack of information, difficulty in defining the business case, and flawed execution highlighting the improvement of including the social dimension into the decision making process (Resta et al., 2016). To examine the spread of LCA methodology across various sectors and its scientific development, Scalbi (2012) worked on mapping groups involved in product life cycle evaluation to address the dissemination and application of the LCA methodology and to identify groups engaged in LCA activities. The study reveals that a growing number of groups involved in LCA activities utilise this methodology for environmental certification purposes as a comprehensive approach to studying the environmental impacts of products and systems, may limit its relevance to more recent developments in the field.

The management and collection of textile waste

The European strategy to increase levels of separate collection of textile waste [8], anticipated by Italian regulations [9], according to Chezzi (2022), includes the introduction of an "Extended Producer Responsibility" (EPR) regime in relation to textile products. In line with these objectives, the National Recovery and Resilience Plan (PNRR) has allocated significant resources to so-called "Textile Hubs" for the establishment of new textile recycling plants from a systemic perspective. In this context, the author introduces RETEX.GREEN [10], to represent a proactive response to upcoming regulatory changes and confirms the growing recognition of Extended Producer Responsibility (EPR) as a viable strategy for addressing sustainability in the textile industry.

Discussing the challenges and strategies associated with treating textile waste, another issue essential due for the industries is the wastewater from textile supply chain. The concept of zero liquid discharge (ZLD) was introduced by Jahan et al. (2022) as a promising approach for sustainable water management for understanding different wastewater treatment techniques to achieve ZLD. Only a small portion of textile waste is collected and recycled because several waste is made of blended textile (Navone et al., 2020). The authors propose a sustainable solution for the recycling of wool fabric blends by enzymatically digesting wool fibres from wool-polyester blends, to separate the wool and recover the polyester fibres, which, retaining their properties, can be reused in new garments or other products and offers.

The importance of implementing a circular economy through proper management of resources that have become waste is at the core of Manco et al.'s research (2016) and the discussion of ecological footprint as a method of evaluating anthropogenic activities. In line with the European Union's recommendations for sustainable development, the scholars highlight the importance of separate collection of urban waste to reduce the extraction of

raw materials and limit the reintroduction of waste products into the environment (Manco et al., 2016). Pay particular attention to the concept of waste (p.238) and its origin (from the verb “to refuse”), they emphasising the shift that has led to considering waste as a resource to be valued thanks to the involvement and awareness-raising of the community (p.272). The social and moral value of waste is a central topic in the theory of waste poetics put forward by Binotto and Payne (2017). In particular, Binotto and Payne focus on the mechanism employed by the fashion industry to prioritise novelty and the first cycle of consumption, while emphasising the tendency to alter the perception of waste through the adoption of zero-waste approaches that reshape, repackage, transform, and “hide” waste under a new guise and attribute a new positive value to these products that led waste to be “accepted” and reintroduced into the value chain.

Sustainable fashion and zero-waste approaches

The ongoing discussions in the field of sustainable fashion and textiles waste combines established frameworks such as systems thinking and design thinking with innovative approaches to address sustainability challenges in this sector (Matthes et al., 2021; Mellick et al., 2021; Solino et al., 2020; Brooks et al., 2017; Gardetti & Torres, 2017). Fletcher in the book “Sustainable fashion and textiles: Design journeys” (2013) states that sustainability, once marginalised, has gained traction among large corporations and is increasingly integrated into various aspects of the industry, including fashion weeks and government initiatives. New methods, materials, and approaches to sustainability were introduced as fostering ecological integrity, choosing materials to minimise environmental impact and optimising supply chain processes to reduce waste and resource consumption. While existing sustainability frameworks focus on metrics or economic value, Mellick et al. (2021) propose to combine the Sustainable Value Chain Analysis (SVCA) approach with the Cambridge Value Mapping Tool (CVMT) to identify sustainable value and opportunities for future value creation.

Sustainability issues in the global textile and fashion value chain are questions linked to various drivers and indicators (Matthes et al., 2021). The environmental threats posed by unbridled clothing consumption demand the adoption of new materials and economic models to mitigate the impacts of clothing production and use, particularly in relation to laundry practices in Britain (Brooks et al., 2017). Water usage and waste generation, moreover to job insecurity and child labour, are a significant environment and social impacts of the textile industry that fashion industry needs to pose as sustainability challenges (Gardetti & Torres, 2017). In response to the negative impacts of fast fashion, the rise of the slow fashion movement has been discussed in academic research, providing insights into its emergence, development and dissemination with the fashion industry with exponential growth particularly in countries like Brazil and the United States (Solino et al., 2020).

In this considerations, take sides the Zero Waste philosophy that focuses itself on “designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them” (Pasricha & Greeninger, 2018) [11]. Also, is a creative and participatory approach to engaging citizens in envisioning desirable “zero” waste futures, aiming to counterbalance predominant technology-centred visions of waste management (van den Eijnden, 2022) and policies (Altamura & Baiani, 2019). Zero waste (ZW) manufacturing put together various techniques for achieving zero waste by means of resource recycling (Awogbemi et al., 2022). Many

scholars investigate the zero-waste approaches as an opportunity to explore innovative aspects of waste management from various perspectives and disciplines. Such as reframing waste to grow recognition of the potential value in waste materials, or the concept of Zero Waste as an effective approach to addressing solid waste issues reshaping the resource supply chain to prioritise reuse and recycling, aiming to minimise waste generation (Awasthi et al., 2021).

In fashion and textile, scholars investigate the zero-waste approach to integrate sustainability practice into fashion design curriculum exploring the effectiveness of teaching zero-waste design within fashion design courses to increase students' awareness of fabric waste generation during the design process (Gam & Banning, 2020). Effort reshaping the pattern-making process. According to Rissanen (2014), 'zero-waste fashion design' (ZWFD) has received considerable attention and interest from fashion media, industry and education since 2008 for providing a useful lens through which we can examine the fashion system and the relationships between and within the fashion industry and fashion users, but also for its focus on designing out pre-consumer fabric waste: zero waste fashion design (Rissanen & McQuillan, 2015). As an apparel production approach, zero-waste implies challenges because it tends to create one-size-fits-most option limiting mass-market applicability (Carrico et al., 2022), needs to be implemented using digital pattern cutting and marker making techniques (Ramkalaon & Sayem, 2020), and, moreover, for the feasibility and desirability of zero-waste fashion design within contemporary fashion (Rissanen, 2013). Some scholars worked on different methods to develop zero-waste patterns. C&P (Cutting and packing) focuses on mathematical and computational techniques for minimising fabric waste in marker planning, while ZWFD (Zero-Waste Fashion Design) provides creative pattern-making solutions to achieve zero fabric waste (ElShishtawy et al., 2022). Transformational Reconstruction (TR), is an innovative pattern-making technique in which the pattern cutting process was integrated into the design progression toward zero-waste resulting in more fitted garments (Saeidi & Wimberley, 2018).

To try to respond to the combination of cheap production of textiles and apparel (McQuillan, 2011), the challenge of waste could be addressed by proposing a User Modifiable Zero Waste Fashion (UMZWF) to democratise fashion production, empower users to engage with garment making and modification, and reduce waste in both production and use (McQuillan et al., 2018) or addressing the potential of three-dimensional (3D) software in zero-waste fashion design. 3D software could transform design practices in industry, education, and research, particularly focusing on its application in reducing fabric wastage during garment production (McQuillan, 2020). Carrico & Kim (2013, 2014) developed a method of resizing garments without making changes to the original pattern shape through carefully planned seam placements with varying widths.

Zero-waste fashion design offers new opportunities for engaging with fashion manufacture, particularly in addressing issues such as fabric utilisation and garment pattern grading (Rissanen, 2013). It can also be a creative pattern making challenge by uniting the roles of designer and patternmaker in a holistic approach to creating garments, considering aesthetics and function simultaneously, states Carrico & Kim (2014) that worked on of McQuillan "design practices" for zero-waste apparel design Shaping Sustainable Fashion (2011), proposing a fifth "design practice" draping the whole cloth with minimal cutting, called "minimal cut". In the context of a sustainable fashion system, other approaches define circular design to understand and recognise the potential for design in creating a circular fashion future as well (Goldsworthy, 2018).

The transition to a circular economy in the textile industry involves re-

thinking traditional linear production models and adopting waste valorization practices (Stanescu, 2021). Various solutions for valorizing textile waste are discussed in literature including recycling into second-hand clothes or new products, upcycling into fibres or composites, using textile waste as energy sources, and utilising it for soil improvement. A growing emphasis on upcycling textile waste to recover materials and energy viewing it as a potential source of carbon and energy within the context of the circular economy (Stanescu, 2021). Advanced upcycling methods in fashion practice, with the specificity of design methods, are centred on revaluation and resignification of waste materials (Bigolin et al., 2022). To address the feasibility of implementing upcycling design and production methods to mitigate this waste, some authors analysed the amount and types of textile waste and fabric leftovers generated in garment production, identified suitable methods for industrial upcycling, and developed innovative design approaches to utilise this waste effectively (Aus et al., 2021). A significant amount of this waste comes from post-consumer textile waste (PCTW) generated from used or second-hand clothing (SHC), waste that is not repurposed or recycled, but rather discarded. This clothing waste, very often fast fashion that helps satiate deeply held desires to mimic luxury fashion trends among young consumers (Joy et al., 2015), could be repurposed as new clothing developing a closed-loop supply chain that can support new product manufacture, divert textile waste, and enable an additional stream of revenue from reclaimed apparel (Lewis et al., 2016).

Conclusions

The academic discourse on textile waste and sustainability in the fashion industry underscores the urgent need for comprehensive strategies to address textile waste and promote circular economy principles. Life cycle assessment methodologies play a crucial role in evaluating the environmental and social impacts of textile products, while waste management strategies such as extended producer responsibility and zero liquid discharge systems offer practical solutions for reducing waste in the supply chain. Additionally, the adoption of zero-waste approaches in fashion design and production, along with the promotion of circular design principles and upcycling techniques, presents promising avenues for achieving a more sustainable and environmentally conscious fashion system. However, further research and collaboration are needed to effectively implement these strategies and drive meaningful change across the industry.

Acknowledgments

Project funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.3 - Call for tender No. 341 of 15/03/2022 of Italian Ministry of University and Research funded by the European Union – NextGenerationEU. Award Number: PE00000004, Concession Decree No. 1551 of 11/10/2022 adopted by the Italian Ministry of University and Research, CUP B83C22004890007. MICS (Made in Italy - Circular and Sustainable).

Spoke 2 Eco-Design strategies: from materials to Product Service Systems – PSS

Footnotes

[1] To verify the truthfulness of this statement, the author is conducting a mapping operation of Italian entities that, at various stages of the supply chain (weaving, manufacturing, design, recycling, etc.), are required to deal with the production and/or management of textile waste and scraps. The mapping aims to identify the moments when this production/management occurs in order to pinpoint best practices.

[2] The European Commission has identified textiles (i.e., apparel and fabrics) as a “priority product category for the circular economy”, encouraging the development of technological applications for textile waste reuse and recycling. Moreover, the European Directive EU 2018/851 obliges Member States to start the separate collection of textile waste by 1 January 2025

[3] Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste <https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A32018L0851>

[4] “The fashion system produces tons of waste every year that end up in landfills, which could be reintegrated into the production cycle. This happens despite the numerous studies that seek to develop optimization systems for reuse possibilities.” (Di Giacomo, 2013, p.3).

[5] The ISPRA report on special waste in 2012 estimated that 37.4% of non-hazardous waste from manufacturing came from the textile, clothing, and tanning industries. ISPRA, Urban Waste Report 2012. <https://www.isprambiente.gov.it/it/pubblicazioni/rapporti/rapporto-rifiuti-urbani-2012>

[6] The authors specifically cite the production reality of Prato as an example of a district long oriented towards the recycling of woollen products and the recovery of textile materials, such as clothing items, by companies or associations that allow for the extension of the product life cycle. Alternatively, small brands and cooperatives employ fabric recovered from warehouse stocks for social sustainability projects. (p.48)

[7] The authors focus their study on the environmental and social life cycle assessment of a knitted garment produced in a textile factory (San Lorenzo Group), located in San Marco d’Alunzio, Messina (Italy), a village situated in the Nebrodi (Sicilian mountains), as an agricultural reality characterised by farmhouses, to identify positive and negative impacts of the product in this specific context and to use the results as an input for the decision-making process in the company. (Lenzo et al., 2018).

[8] Starting from 2025 (Dir. 2018/851/EU).

[9] Italian legislation has moved up the deadline to January 1, 2022 (Legislative Decree No. 116/2020).

[10] <https://retex.green/>

[11] An updated definition of Zero Waste, adopted by the ZWIA board on December 2018, aligning the definition to the guiding principles of the Zero Waste Hierarchy, states: “Zero Waste: The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health.” Last updated December 20th, 2018. <https://zwia.org/zero-waste-definition/>

References

1. Altamura, P., & Baiani, S. (2019). Superuse and upcycling through design: approaches and tools. *IOP Conference Series: Earth and Environmental Science*, 225, 012014. <https://doi.org/10.1088/1755-1315/225/1/012014>
2. Aus, R., Moora, H., Vihma, M. et al. Designing for circular fashion: integrating upcycling into conventional garment manufacturing processes. *Fash Text* 8, 34 (2021). <https://doi.org/10.1186/s40691-021-00262-9>
3. Awasthi, A., Cheela, V. R. S., D'Adamo, I., Iacovidou, E., Islam, M., Johnson, M., Miller, T. R., Parajuly, K., Parchomenko, A., Radhakrishan, L., Min, Z., Zhang, C., & Li, J. (2021). Zero waste approach towards a sustainable waste management. *Resources, Environment and Sustainability*, 3, 100014. <https://doi.org/10.1016/j.resenv.2021.100014>
4. Awogbemi, O., Von Kallon, D. V., & Bello, K. A. (2022). Resource Recycling with the Aim of Achieving Zero-Waste Manufacturing. *Sustainability*, 14(8), 4503. <https://doi.org/10.3390/su14084503>
5. Bastos, J., Rizzari, M., Agosti, E., D'Alonzo, V., Hoffmann, C., & Vettorato, D. (2021). Analisi dello stato dell'arte: Report sui settori e attività produttive per promuovere l'Economia Circolare.
6. Bigolin, R., Blomgren, E., Lidström, A., De Oliveira, S. M., & Thornquist, C. (2022). Material Inventories and Garment Ontologies: Advancing upcycling Methods in fashion practice. *Sustainability*, 14(5), 2906. <https://doi.org/10.3390/su14052906>
7. Binotto, C., & Payne, A. (2017). The poetics of waste: Contemporary fashion practice in the context of wastefulness. *Fashion Practice*, 9(1), 5–29. <https://doi.org/10.1080/17569370.2016.1226604>
8. Bonifazi, G., Gasbarrone, R., Palmieri, R., & Serranti, S. (2022). End-of-Life Textile Recognition in a Circular Economy Perspective: A Methodological Approach Based on Near Infrared Spectroscopy. *Sustainability*, 14(16), 10249. <https://www.mdpi.com/2071-1050/14/16/10249>
9. Brooks, A., Fletcher, K., Francis, R. A., Rigby, E., & Roberts, T. G. (2017). Fashion, sustainability, and the Anthropocene. *Utopian Studies*, 28(3), 482–504. <https://doi.org/10.5325/utopianstudies.28.3.0482>
10. Carrico, M., Drago, S. L., McKinney, E., Stannard, C., Moretz, C., & Rougeaux-Burnes, A. (2022). An inquiry into gradable zero-waste apparel design. *Sustainability*, 14(1), 452. <https://doi.org/10.3390/su14010452>
11. Carrico, M. and Kim, V. (2014) Expanding zero-waste design practices: a discussion paper, *International Journal of Fashion Design, Technology and Education*, 7(2), 58-64.
12. Carrico, M., & Kim, V. (2013). Expanding zero-waste design practices: a discussion paper. *International Journal of Fashion Design, Technology and Education*, 7(1), 58–64. <https://doi.org/10.1080/17543266.2013.837967>
13. Chezzi, M. (2022). Il riciclo dei rifiuti tessili e la responsabilità del produttore: La funzione di general contractor per il waste management. *GeoTrade : Rivista Di Geopolitica e Commercio Estero* : 3, 2022, 88–91. <https://doi.org/10.1400/288848>
14. Di Giacomo, M. (2013). IL "FINE VITA" DEI PRODOTTI NEL SISTEMA MODA. ARES, 2. <https://informatex.it/wp-content/uploads/2017/06/Il-fine-vita-dei-prodotti-nel-sistema-moda.pdf>
15. ElShishtawy, N., Sinha, P., & Bennell, J. A. (2022). A comparative review of zero-waste fashion design thinking and operational research on cutting and packing optimization. *International Journal of Fashion Design, Technology and Education*, 15(2), 187–199. <https://doi.org/10.1080/17543266.2021.1990416>
16. Fiasco, Federico (A.A. 2017/2018) *Impresa 4.0: esame della situazione attuale e prospettive evolutive nel manifatturiero italiano: il caso Beste S.p.a.* Tesi di Laurea in Economia e gestione delle imprese, LUISS Guido Carli, relatore Maria Isabella Leone, pp. 65. [Tesi di Laurea triennale]
17. Fletcher, K. (2014). *Sustainable Fashion and Textiles: Design Journeys* (2nd ed.). Rout-

- ledge. <https://doi.org/10.4324/9781315857930>
18. Fondazione per lo sviluppo sostenibile & FISE UNICIRCULAR (Unione Imprese Economia Circolare). (2022). *L'Italia del riciclo 2021. Parte 1. Approfondimento sul settore tessile*. Fondazione per lo sviluppo sostenibile e FISE UNICIRCULAR. <https://www.ecocerved.it/media/l-italia-del-riciclo-2021-estratto>
 19. Gam, H. J., & Banning, J. (2020). Teaching Sustainability in Fashion Design Courses Through a Zero-Waste Design Project. *Clothing and Textiles Research Journal*, 38(3), 151-165. <https://doi.org/10.1177/0887302X20906470>
 20. Gardetti, M. A., & Torres, A. L. (Eds.). (2013). *Sustainability in fashion and textiles: values, design, production and consumption*. Routledge & CRC Press. Retrieved February 25, 2024, from <https://www.routledge.com/Sustainability-in-Fashion-and-Textiles-Values-Design-Production-and-Consumption/Gardetti-Torres/p/book/9781906093785>
 21. Gazzola, P., Pavione, E., Grechi, D., & Raimondi, V. (2020). L'economia circolare nella fashion industry, ridurre, riciclare e riutilizzare: alcuni esempi di successo. *Economia Aziendale Online*, 11(2), 165-174. <http://riviste.paviauniversitypress.it/index.php/ea/article/view/2036/2177>
 22. Giorgianni, M. (2022). POSTFASHION E «RIVOLUZIONE DELLA SOSTENIBILITÀ» NELL'ECONOMIA GLOBALIZZATA. *COMPARATIVE LAW REVIEW*, 12(1). <http://www.comparativelawreview.unipg.it/index.php/comparative/article/view/224>
 23. Goldsworthy, K., Earley, R., & Politowicz, K. (2018). Circular Speeds: A Review of Fast & Slow Sustainable Design Approaches for Fashion & Textile Applications. *Journal of Textile Design, Research and Practice*, 6(1), 42–65. <https://doi.org/10.1080/20511787.2018.1467197>
 24. Jahan N, Tahmid M, Shoronika AZ, Fariha A, Roy H, Pervez MN, Cai Y, Naddeo V, Islam MS. A Comprehensive Review on the Sustainable Treatment of Textile Wastewater: Zero Liquid Discharge and Resource Recovery Perspectives. *Sustainability*. 2022; 14(22):15398. <https://doi.org/10.3390/su142215398>
 25. Joy, A., Sherry, J. F., Venkatesh, A., Wang, J. J., & Chan, R. Y. K. (2012). Fast fashion, sustainability, and the ethical appeal of luxury brands. *Fashion Theory*, 16(3), 273–295. <https://doi.org/10.2752/175174112x13340749707123>
 26. Lacy, P., Long, J., Orneli, S., Spindler, W. (2021). *Il manuale della circular economy: Realizzare il vantaggio circolare*. Italia: Egea.
 27. Lenzo P, Traverso M, Mondello G, Salomone R, Ioppolo G. Sustainability Performance of an Italian Textile Product. *Economies*. 2018; 6(1):17. <https://doi.org/10.3390/economies6010017>
 28. Lewis, T., Park, H., Netravali, A. N., & Trejo, H. (2016). Closing the loop: a scalable zero-waste model for apparel reuse and recycling. *International Journal of Fashion Design, Technology and Education*, 10(3), 353–362. <https://doi.org/10.1080/17543266.2016.1263364>
 29. Manco, I., & Cordoni, C., Vaccari, V., (2017). *Il Ciclo del Rifiuto*. *Economia Aziendale Online*, 7(4), 237–275. <https://doi.org/10.13132/2038-5498/7.4.237-275>
 30. Matthes, A., Beyer, K., Cebulla, H., Arnold, M. G., & Schumann, A. (Eds.). (2021). *Sustainable textile and fashion value chains: Drivers, concepts, theories and solutions*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-22018-1>
 31. Mazzanti, M., & Nicolli, F. (2012). Firm's social and economic role within Local-Global sustainability strategies: EU frameworks, environmental innovations, public goods. *Economia Dei Servizi*, 2, 249–272. <https://doi.org/10.2382/38876>
 32. McKinsey & Company. (2022). *Scaling textile recycling in Europe—turning waste into value*. McKinsey & Co. <https://www.mckinsey.com/~media/mckinsey/industries/retail/our%20insights/scaling%20textile%20recycling%20in%20europe%20turning%20waste%20into%20value/scaling%20textile%20recycling%20in%20europe%20turning%20waste%20into%20value.pdf?shouldIndex=false>
 33. McQuillan, H. (2020). Digital 3D design as a tool for augmenting zero-waste fashion design practice. *International Journal of Fashion Design, Technology and Education*, 13(1), 89–100. <https://doi.org/10.1080/17543266.2020.1737248>
 34. McQuillan, H., Archer-Martin, J., Menzies, G., Bailey, J., Kane, K., & Fox Derwin, E. (2018). Make/use: A system for open source, user-modifiable, zero waste fashion practice. *Fashion Practice*, 10(1), 7–33. <https://doi.org/10.1080/17569370.2017.1400320>
 35. McQuillan, H. (2011). Zero-waste design practice: Strategies and risk taking for garment design. In *Shaping Sustainable Fashion*. Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9780203126172-12/2-4-zero-waste-design-practice-holly-mcquillan>
 36. Mellick, Z., Payne, A., & Buys, L. (2021). From fibre to fashion: Understanding the value of sustainability in global cotton textile and apparel value chains. *Sustainability*, 13(22), 12681. <https://doi.org/10.3390/su132212681>
 37. Navone, L., Moffitt, K., Hansen, K. A., Blinco, J. P., Payne, A., & Speight, R. (2020). Closing the textile loop: Enzymatic fibre separation and recycling of wool/polyester fabric blends. *Waste Management*, 102, 149–160. <https://doi.org/10.1016/j.wasman.2019.10.026>
 38. Noè, C., & Magni, A., (2017). *Innovazione e sostenibilità nell'industria tessile*. 1–137.

- <https://www.torrossa.com/it/resources/an/5085233>
39. Pasricha, A., & Greeninger, R. (2018). Exploration of 3D printing to create zero-waste sustainable fashion notions and jewelry. *Fashion and Textiles*, 5(1), 30. <https://doi.org/10.1186/s40691-018-0152-2>
 40. Pezzoli, S., & Vaghi, S. (2019). VALUTARE L'ECONOMIA CIRCOLARE SECONDO UN APPROCCIO DI LIFE CYCLE THINKING: L'ATLANTE ITALIANO DELL'ECONOMIA CIRCOLARE. *Ingegneria Dell'Ambiente*, 6(2). <https://doi.org/10.32024/ida.v6i2.211>
 41. Pratt, A., Borriore, P., Lavanga, M., & D' Ovidio, M. (2012). International change and technological evolution in the fashion industry. In Mauro Agnoletti, Andrea Carandini, Walter Santagata (eds), *Essays and Researches. International Biennial of Cultural and Environmental Heritage / Studi e ricerche. Biennale internazionale dei beni culturali ed ambientali. Florence/Firenze 2012* (pp. 359–394). Retrieved from <http://hdl.handle.net/1765/51737>
 42. Ramkalaon, S., & Sayem, A. S. M. (2020). Zero-Waste Pattern Cutting (ZWPC) to tackle over sixty billion square metres of fabric wastage during mass production of apparel. *Journal of the Textile Institute*, 112(5), 809–819. <https://doi.org/10.1080/00405000.2020.1779636>
 43. Rana, S., Karunamoorthy, S., Parveen, S., & Fanguero, R. (2015). Life cycle assessment of cotton textiles and clothing. In *Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing* (pp. 195–216). Elsevier. <https://doi.org/10.1016/B978-0-08-100169-1.00009-5>
 44. Resta, B., Gaiardelli, P., Pinto, R., & Dotti, S. (2016). Enhancing environmental management in the textile sector: An Organisational-Life Cycle Assessment approach. *Journal of Cleaner Production*, 135, 620–632. <https://doi.org/10.1016/j.jclepro.2016.06.135>
 45. Rissanen, T., & McQuillan, H. (2015). *Zero waste fashion design*. Bloomsbury Publishing.
 46. Rissanen, T. (2014). *The fashion system through a lens of zero-waste fashion design*. In *Routledge Handbook of Sustainability and Fashion*. Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9780203519943-24/fashion-system-lens-zero-waste-fashion-design-timo-rissanen>
 47. Rissanen, T. I. (2013). *Zero-waste fashion design: A study at the intersection of cloth, fashion design and pattern cutting* [Thesis]. <https://opus.lib.uts.edu.au/handle/10453/23384>
 48. Saccani, N., Bressanelli, G., & Visintin, F. (2023). Circular supply chain orchestration to overcome Circular Economy challenges: An empirical investigation in the textile and fashion industries. *Sustainable Production and Consumption*, 35, 469–482. <https://doi.org/10.1016/j.spc.2022.11.020>
 49. Saeidi, E., & Wimberley, V. (2017). Precious cut: exploring creative pattern cutting and draping for zero-waste design. *International Journal of Fashion Design, Technology and Education*, 11(2), 243–253. <https://doi.org/10.1080/17543266.2017.1389997>
 50. Salvi, T., Borsacchi, L., & Barberis, V. (2021). Modelli integrati di governance di economia circolare a livello urbano Il caso di Prato. *CONTESTI*, 97.
 51. Scalbi, S. (2012). *MAPPATURA NAZIONALE DEI GRUPPI E DELLE ATTIVITÀ NEL CAMPO DELL'ANALISI DEL CICLO DI VITA (LCA)*. <https://www.enea.it/it/seguici/pubblicazioni/pdf-volumi/V2013MappaturaLCA2012.pdf>
 52. Solino, L. J. S., Teixeira, B. M. de L. ., & Dantas, Ítalo J. de M. (2020). The sustainability in fashion: a systematic literature review on slow fashion. *International Journal for Innovation Education and Research*, 8(10), 164–202. <https://doi.org/10.31686/ijer.vol8.iss10.2670>
 53. Stanescu, M. D. (2021). State of the art of post-consumer textile waste upcycling to reach the zero waste milestone. *Environmental Science and Pollution Research*, 28(12), 14253–14270. <https://doi.org/10.1007/s11356-021-12416-9>
 54. Vaccari, A., & Cerulli, M. C. (2014). *Textile and Fashion Hub: come estendere il ciclo di vita di tessuti e altri materiali della moda*. <https://air.iuav.it/handle/11578/273422>
 55. Van Den Eijnden, T., Baibarac-Duignan, C., De Lange, M., & De Goede, M. (2022). Materials and modes of translation: Re-imagining inclusive “zero”-waste futures. *Frontiers in Sustainable Cities*, 4. <https://doi.org/10.3389/frsc.2022.958423>
 - 56.