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Solutions for Textile Integrated Circular Economy

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Executive Summary

Prato is internationally recognised for its expertise in mechanical recycling of wool, making it a leader in circular textiles. The city accounts for approximately 3% of European textile production and has significant potential to inspire other regions in circular practices. However, despite this strong heritage, Prato faces challenges related to traceability of recycled materials and governance across its value chain. While pre-consumer textile waste is a key asset for the city, data on collection, sorting, and treatment is lacking, and remains under assumption of sufficient compliance and proper handling. Establishing robust tracking systems could ensure that Prato's recycled fibres are verified and traceable, supporting its reputation as a circular leader.

Employment in the textile sector in Prato is driven by manufacturing, with 40,032 jobs, but data on circular employment is limited. The city has around 600 jobs in textile collection, sorting, and recycling, though these figures are not fully verified. Employment is also seen in repair (478 jobs) and rental services, while second-hand retail remains underdeveloped. Further research is needed to accurately assess the contribution of circular practices to local employment and identify opportunities for growth. Given Prato's role as a major textile hub, expanding its circular workforce could enhance economic resilience while supporting sustainable development.

Italian consumers, particularly in northern regions such as Milan, benefit from higher purchasing power, with an average of €25,077 per capita—41% above the national average and approximately 70% above the European average.[1] This financial advantage suggests that many consumers have the capacity to choose more sustainable and circular products. However, this potential is limited by persistent cultural stigmas around second-hand items, alongside other barriers such as perceived high costs, concerns about quality, and a general lack of trust. As a result, even consumers with greater spending power often remain hesitant to engage with circular options.

The city has strong accessibility to circular textile services, with 96% of residents able to reach at least one recycling, reuse, or repair point within a 15-minute walk, and 100% within a 10-minute drive. These services are most densely concentrated in central areas, where population density is highest, rather than being distributed based on income levels. However, despite high accessibility, engagement with circular options is hindered by cultural stigma, costs, and limited repair services.

The estimated climate impact of post-consumer textile flows in Prato is 650 thousand tonnes of CO2e per year. Environmental impacts vary by material and treatment methods, but reducing unnecessary consumption remains the most effective strategy for lowering emissions. Local initiatives like Re-Waste demonstrate the potential for reducing environmental impacts through mechanical recycling without additional dyeing.[2] However,

[1] https://fashionunited.com/statistics/global-fashion-industry-statistics/italy

[2] https://www.mics.tech/en/projects/2-08-re-waste-circular-ecosystems-in-textile-chain/

significant impacts like microplastics are not yet fully integrated into scientific models, suggesting an even greater potential for impact reduction through circular strategies.

Dissemination level: public

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1. Introduction to the territory profile

1.1 Context setting

The global textile industry is 0.3% circular: of the 3.25 billion tonnes of materials it consumes each year, over 99% come from virgin sources.[3] In part, this metric is bogged down by high virgin material consumption, with per capita fibre consumption rising significantly over the decades: from 8.3 kilograms in 1975 to 14.6 kilograms in 2022. This is expected to grow by a further 7.4% per year up to 2030. At the same time, textile recycling is lagging—the strong majority (61.4%) of discarded textiles are landfilled or incinerated. Just 8% is reused or exported, 6.3% ends up in cascading recycling, and 2.2% is lost during collection or sorting.

The current scale of textile consumption is linked to numerous impacts: from climate change to water eutrophication and water scarcity. Social impacts, including labour rights violations, health hazards and threats to livelihoods in producing communities, are also pronounced. The circular economy offers a means to address these challenges, through various R-strategies such as **Reduce, Reuse, Repair, Repurpose,** and **Recycle.**

1.2 SOLSTICE: 5R solutions for textile integrated circular economy

The SOLSTICE project aims to address the key social, environmental and technical challenges posed by the textile industry through a circular economy lens. Funded by the European Union's Horizon Europe research and innovation programme under grant agreement No. 101134989, SOLSTICE is taking steps towards a circular textile industry through the implementation of pilot projects in four territories: Berlin, Grenoble, Catalonia, and Prato. The project will showcase how circular economy practices can be tailored to and implemented across the textile industry.

1.3 Territory profile: goal, methodology and structure

In collaboration with the four territories studied, Circle Economy led a current state analysis of the textile ecosystem, including current circular practices. This analysis provides insight into areas where immediate action is needed and informs the selection of relevant circular practices in each of the four territories. A mixed-methods approach was used to analyse this current state: first, describing the national and local textile industry context; giving an overview of relevant national and regional textile policies; and conducting a detailed analysis for the territories in focus. This includes a material flow analysis to map textile flows across the value chain, a baseline analysis of employment in the territory's textile value chain, a consumer behaviour analysis vis a vis textile consumption and circular solutions, and an environmental impact assessment to determine the current consequences of the textile value chain in each territory. The final chapter for each territory

[3] Circle Economy. (2024). *The circularity gap report textiles.* Amsterdam: Circle Economy. Retrieved from: CGR Website

profile extracts key findings to formulate recommendations for the design of the circular textile pilot project.

2. The current state of the circular textile landscape

2.1 National industry context

Italy's textile industry has long been a cornerstone of its economy, deeply woven into the country's industrial and cultural fabric. In 2023, Italy solidified its global standing by exporting US$37.1 billion in textiles, making it the sixth largest textile exporter in the world.[4] At the same time, it imported US$30 billion worth of textiles, ranking as the fifth largest importer.[5] This trade activity highlights the country's dual role as both a producer of high-quality textiles and a key consumer of raw and finished materials.

Beyond the numbers, textiles and fashion remain Italy's second most important industry after mechanical engineering,[6] supporting a vast network of 45,000 companies across the country.[7] Among them, the production of technical textiles plays a leading role, accounting for 22% of total textile output.[8] Italy has become the top producer in Europe and the fourth largest globally in this field, with over 60% of its technical textiles exported to markets worldwide.[9] Yet, despite this strength, the industry has faced notable shifts. While textile exports grew 4.81% between October 2023 and October 2024, and imports rose by 3.36%,[10] textile producers have seen a 7.7% drop in revenue. The decline has been most evident in wool and knitted fabrics,[11] reflecting broader challenges within global trade and consumer demand.

At the same time, Italy has been pushing forward in textile sustainability. Prato, the heart of Italy's textile recycling efforts, has been at the forefront of processing wool and mixed fibres, contributing significantly to the country's circular economy goals. As part of its National Recovery and Resilience Plan, Italy has set an ambitious target: to regenerate 100% of textile waste in the coming years by expanding separate collection, recovery, and recycling infrastructure.[12] In fact, Italy took a bold step ahead of the EU by introducing mandatory textile waste separation on January 1, 2022—three years before the EU's 2025 deadline.[13] [14] By 2020, 73% of Italian municipalities had already adopted separate collection, which

[4] https://oec.world/en/profile/bilateral-product/textiles/reporter/ita

[5] https://oec.world/en/profile/bilateral-product/textiles/reporter/ita

[6] https://itma.com/admin/itma/media/itma/ITMA/The_Italian_Textile_Industry/The-Italian-Textile-Industry.pdf

[7] https://itma.com/admin/itma/media/itma/ITMA/The_Italian_Textile_Industry/The-Italian-Textile-Industry.pdf

[8] https://www.acimit.it/en/the-italian-textile-industry-la-ricerca-firmata-itma-sul-nostro-paese/

[9] https://www.acimit.it/en/the-italian-textile-industry-la-ricerca-firmata-itma-sul-nostro-paese/

[10] https://oec.world/en/profile/bilateral-product/textiles/reporter/ita

[11] https://ww.fashionnetwork.com/news/Revenue-of-italian-textiles-industry-drops-7-7-in-2024,1699690.html

[12] https://itma.com/admin/itma/media/itma/ITMA/The_Italian_Textile_Industry/The-Italian-Textile-Industry.pdf

[13] https://task36.ieabioenergy.com/news/separated-collection-of-textile-waste-in-italy-problems-to-face-to-improve-recycling/

[14] https://www.dedastealth.com/news/italy-leads-the-way-in-recycling-textile

resulted in lowering the amount of textile waste in the municipal waste down to 5.7%, which is close to the EU-27 average[15]. In 2021, Italy collected around 154,000 tonnes of textile waste, a figure that underscores both progress and the need for further improvements.[16]

While the country boasts a vibrant second-hand market, textile recycling remains a challenge. Currently, only 10% of consumed textiles—about 157,000 tonnes—are collected for recycling.[17] The ERP Italia Textile Consortium has set an ambitious goal of achieving a 50% recycling rate by 2035,[18] but reaching this milestone will require significant investment in recycling technologies and infrastructure. Though Italy has Europe's largest network of sorting and recycling facilities, especially in Prato, gaps remain in data transparency due to overlaps between reuse and recycling processes.[19]

Looking ahead, the industry faces two key challenges: transitioning to more sustainable production methods and accelerating the digitisation of supply chains, ensuring that small and medium-sized enterprises are included in this transformation.[20] Meanwhile, research and innovation are increasingly focused on new raw materials and high-performance textiles, driving the industry toward a more sustainable and technologically advanced future.[21]

2.2 Local industry context

Prato, Italy, is famed for its textile industry. The city's textile district is amongst the largest industrial districts in Italy and produces approximately 3% of Europe's textiles.[22] Strong technical education and research, and significant investments into innovative machinery also give Prato's textile industry an edge, enabling it to be a frontrunner in highly specialised production.[23] More broadly speaking, Italy's expertise in the textile and garment industry and its collaborative approach throughout the supply chain enable it to respond quickly and effectively to shifting industry needs. This provides a strong foundation for future development towards sustainability goals.[24]

Prato's textile industry already boasts a strong culture of circularity, reusing scrap textiles and recycling wool has been commonplace since the mid-19th century, at that time largely

[15] https://www.eea.europa.eu/publications/management-of-used-and-waste-textiles

[16] https://task36.ieabioenergy.com/news/separated-collection-of-textile-waste-in-italy-problems-to-face-to-improve-recycling/

[17] https://textileinsights.in/consortium-aims-to-recycle-50-italian-textile-waste-by-2035/

[18] https://textilevaluechain.in/news-insights/business-policy-news-insights/erps-ambitious-goal-recycling-50-of-italys-textile-waste-by-2035

[19] https://dress-ecode.com/en/tackling-textile-waste-in-europe-germany-france-and-italy-under-the-loop/

[20] https://itma.com/admin/itma/media/itma/ITMA/The_Italian_Textile_Industry/The-Italian-Textile-Industry.pdf

[21] https://itma.com/admin/itma/media/itma/ITMA/The_Italian_Textile_Industry/The-Italian-Textile-Industry.pdf

[22] Circular City Funding Guide (n.d.) Prato: building on existing local circular practices. Retrieved from: Circular City Funding Guide Website

[23] Unioncamere (n.d.) The Textiles of Prato. Retrieved from: Arts & Culture Google

[24] CBI. (2024, February). Which European Countries offer the most opportunities for recycled fashion. Retrieved from: CBI Netherlands Ministry of Foreign Affairs Website

driven by necessity.[25] This led to Prato being considered among the most innovative industrial cities in Italy, with textile waste management in the post-war period considered a key contributing factor to the city's development.[26] The city's sustainable practices have historically been supported by favourable geographical conditions, from abundant water and resource supplies to beneficial road connections.[27]

Today, Prato's textile district runs according to principles of industrial symbiosis, with various micro, small and medium enterprises along the value chain collaborating to exchange knowledge and generate and reproduce water, energy, textile by-products and waste. The waste of one production process may become the resource of another, bringing a range of environmental benefits: the construction of a centralised treatment plant for industrial wastewater in the early 1980s, for example, has allowed for treated water to be reused in textile production.[28] These built-in circular mechanisms serve as the foundation for the City's Circular Economy Strategy today.[29]

Prato's waste management approach builds on that of Italy's more broadly: at the national level, post-consumer waste is deposited in roadside dumpsters and collected by authorised parties. Since 2017, when textile waste was classified as 'special waste', separate disposal bins have been required, leading to improvements in collection. However, significant challenges remain—particularly in effectively processing and recycling the collected waste. A key issue is the lack of strong coordination between different stages of the recycling process, making it difficult to establish efficient synergies across sorting, processing and reuse.

To address these challenges, Prato has taken a more integrated approach by exploring how textile waste can be reused in production chains across public and private organisations.[30] With a membership of more than 200 enterprises, the Prato-based Italian Recycled Textile Association (ASTRI) has successfully established a network of organisations prioritising textile recycling.[31] The region has also developed a 'Cardato recycled' trademark for locally-produced recycled wool fabrics and yarns, with strict requirements: products displaying the

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[25] Circular City Funding Guide (n.d.) Prato: building on existing local circular practices. Retrieved from: Circular City Funding Guide Website

[26] Borsacchi, L., Barberis, V. & Pinelli, P. (2018). Circular economy and industrial symbiosis : The role of the municipality of Prato within the EU Urban Agenda partnership. Retrieved from: European Circular Economy Stakeholder Platform

[27] Coppola, M.C., Giorgi, D., Stasi, Renato. & Tufarelli, M. (2022). Sustainability in the Prato Textile District: Vanguard and Tradition. *Pages on Arts and Design,* 15(22), 87-109. Retrieved from: Sustainability in the Prato Textile District: Vanguard and Tradition

[28] Borsacchi, L., Pinelli, P. & Tacconi, T. (2021). "Prato Circular City": an integrated strategy to accelerate the circular urban transition through innovation, regeneration, cohesion. *Proceedings of the 27th Annual Conference of the International Sustainable Development Research Society*, 719-729. Retrieved from FLORE (FLOrence REsearch) Website

[29] Circular City Funding Guide (n.d.) Prato: building on existing local circular practices. Retrieved from: Circular City Funding Guide Website

[30] Borsacchi, L., Barberis, V. & Pinelli, P. (2018). Circular economy and industrial symbiosis : The role of the municipality of Prato within the EU Urban Agenda partnership. Retrieved from: European Circular Economy Stakeholder Platform

[31] ASTRI (n.d.) Italian Recycled Textile Association. Retrieved from: ASTRI Website

trademark must first undergo a full life cycle assessment created by Prato's textile industry stakeholders. This is among the first attempts in Europe to provide a simplified life cycle analysis method, thus making it accessible to small and medium-sized enterprises.[32]

Despite these advancements, illegal textile disposal remains a persistent challenge. Due to the high volume of textile waste generated by Prato's manufacturing sector, cases of unlawful waste dumping have been reported. In one case, a company in Prato transported waste approximately 80 kilometres to Siena, where it was illegally disposed of. Additionally, Sei Toscana's video surveillance uncovered 12 cases of abandoned waste, amounting to over 52 thousand kilograms.[33] These instances highlight the ongoing gaps in enforcement and the need for more effective monitoring and waste processing infrastructure. To combat these issues, Prato has invested in modernising its waste management system, focusing on building new treatment plants and upgrading existing facilities to enhance the efficiency of processing and recycling procedures.[34]

3. Governance & policy overview

Italy's *National Strategy for Circular Economy*, formulated in line with the EU's *Circular Economy Action Plan,* was adopted as part of the country's *Recovery and Resilience Plan* in 2021. The *Strategy* includes reforms to Extended Producer Responsibility (EPR) schemes and Consortia systems—the collaborative organisations that collectively manage waste in compliance with EPR regulations. These consortia, such as Corertex Consortium (based in Prato),[35] Ecotessili, EPR Italia Tessile, and Retex Green, work to ensure the proper collection, treatment, and recycling of textile waste. In addition to these reforms, the Strategy also establishes criteria for Green Public Procurement across key sectors of construction, textiles, plastics and electrical and electronic waste.[36] [37] The *National Waste Management Programme*, produced in line with the EU waste directive, also centres on the preparation of waste for reuse, recycling and recovery.[38] The textile industry is a particularly important focus area for the Italian government, which has put forward the ambitious goal of recycling 50% of textile waste by 2035. Significant investment has been allocated to improving Italy's separate collection network and creating new plants for recovery and recycling. An EPR scheme specifically for textiles is also in the works, with a draft decree issued early 2023.[39]

[32] CBI. (2024, February). Which European Countries offer the most opportunities for recycled fashion. Retrieved from: CBI Netherlands Ministry of Foreign Affairs Website

[33] https://www.notizie.it/en/special-waste-abandoned-three-reported-for-illegal-disposal/#google_vignette

[34] https://commission.europa.eu/projects/waste-facility-prato_en

[35] https://corertex.it/en/

[36] GreenWeave. (August, 2022). Extended Producer Responsibility: EPR for Textiles. Retrieved from: Nazena Website

[37] EEA: European Topic Centre Circular economy and resource use. (2022). Circular Economy Country Profile-Italy. Retrieved from: EEA Website

[38] EEA: European Topic Centre Circular economy and resource use. (2022). Circular Economy Country Profile-Italy. Retrieved from: EEA Website

[39] CBI. (2024, February). Which European Countries offer the most opportunities for recycled fashion. Retrieved from: CBI Netherlands Ministry of Foreign Affairs Website

The *Tuscany Regional Plan for Circular Economy* promotes improved waste management and waste reduction in the region and includes an established working group for the textile manufacturing sector and its associated waste streams. The plan also sets the goal of developing more reuse centres and recovery plants alongside increased separate waste collection and recycling.[40] The *Tuscany Textile Pact,* an agreement between the Region of Tuscany and the Municipality of Prato, aims to establish stable and reliable supply chains for the management of textile waste. This includes processing waste for reuse where possible or directing it to incineration plants or landfills where reuse is not possible. Under the pact, producers of waste—recoverable or not—are required to classify and pay for their waste. Addressing a regional shortage in waste treatment facilities, the pact proposes building capacity, including a platform managed by ALIA, the regional waste management company. This platform, which is still undergoing the necessary authorisation process, will oversee the collection, characterisation, and initial processing of textile waste, preparing it for recovery or disposal at appropriate facilities.[41]

Governance at the city level: The City of Prato is firmly committed to transitioning to a circular economy, having represented Italy as part of the *Partnership for Circular Economy* under the EU *Urban Agenda on the Circular Economy* since 2016. Through this partnership, Prato has a dedicated task force for developing its circular economy strategy,[42] and aims to stimulate the reuse, repair, refurbishment, and recycling of existing materials and products while creating new job opportunities. The ongoing *Prato Circular City* project, launched in 2018, is also centred on furthering the City's circular transition through city governance, participatory action and collaboration with various stakeholders. Within Prato's renowned textile sector, the project fosters innovation in production processes, supporting waste reduction and material reuse to minimise waste disposal in landfills.[43] Four circular economy projects are already underway in Prato: the Greenpeace Detox project, for example, brings together 20 textile manufacturing companies aiming to eliminate hazardous substances from the textile production cycle.[44]

The City Administration is also actively including circular strategies in its innovation and development policies, with impacts on building design, the development of renewable energy systems, sustainable urban mobility, bioeconomy, and production systems based on recovery, reuse and recycling.[45] Similarly, the *Prato al Futuro* development strategy centres on sustainability, innovation and social cohesion, with emphasis on the circular transition—particularly for the textile industry. It aims to use new technologies to enhance

[40] Toscana Notizie. (March, 2023). Rifiuti, approvato il Piano regionale dell'Economia Circolare. Retrieved from: Toscana Notizie Website

[41] Confindustria Toscana Nord. (2020). Patto Tessile. Retrieved from: Confindustria Toscana Nord

[42] Circular Design Atlas. (2018). Prato Circular City. Retrieved from: TU delft Circular Design Atlas

[43] https://circularcitiesdeclaration.eu/cities/prato

[44] Confindustria Toscana Nord. (2016). Detox Campaign: Sustainability of textile supply chain. Retrieved from: Confindustria Toscana Nord

[45] Borsacchi, L., Pinelli, P. & Tacconi, T. (2021). "Prato Circular City": an integrated strategy to accelerate the circular urban transition through innovation, regeneration, cohesion. *Proceedings of the 27th Annual Conference of the International Sustainable Development Research Society*, 719-729. Retrieved fromL FLORE (FLOrence REsearch) Website

the reuse and recycling of textiles, reduce the environmental impact of textile production, minimise waste, support local businesses in adopting circular practices, partner with education institutes to promote circularity, ensure the involvement of marginalised communities and promote green job creation.[46]

4. City-level analysis

4.1 Textile ecosystem

4.1.1 Methodology

Approach

This spatial analysis examines the distribution of key locations within Prato's circular textile ecosystem and their accessibility to residents. Accessibility refers to the ease with which people can reach a location or 'point of interest' (POI). The analysis follows a structured approach, beginning with the compilation of an inventory of POIs related to the circular textile ecosystem. This is followed by the calculation of travel times to these POIs using open-source road data, considering both walking and driving. Finally, the analysis assesses how many people have good access to these POIs based on population and socioeconomic data, exploring potential links between accessibility and socioeconomic profiles. A more detailed explanation of the methodology is available in the Methodology Document.

Territory and socioeconomic context

This spatial analysis focuses on the city of Prato, which is one of the seven municipalities in the province of Prato. In the absence of survey data on acceptable travel times, the analysis applies a threshold of 15 minutes for walking and ten minutes for driving as the maximum acceptable travel time to reach a POI. To examine whether accessibility varies across population strata, we employed data on the average household income per UTOE (*Unità territoriali organiche elementari*), which are sub-municipal zoning areas created by aggregating smaller census areas.[47]

POI collection

To compile an inventory of POIs within Prato's circular textile ecosystem, publicly available bottom-up sources were collected. Additionally, establishments related to secondhand clothing shops and textile and apparel repair services were identified through queries to the Google Places API.[48] The analysis focuses on four 'R-categories' of POIs: reuse, repair, rental, and recycle. Reuse locations facilitate textile reuse through selling, exchanging, or giving away used textiles, including secondhand shops, donation points, and clothing swap initiatives. Repair services extend the lifespan of textile products and include clothing and

[46] Prato Al Futuro. (2016). Prato Al Futuro. Retrieved from: Prato Al Futuro

[47] Agnoletti, C., Ferraresi, T., Piccini, L., Turchetti S. *Le attività economiche e la funzione residenziale nel sistema pratese: struttura, dinamica e prospettive*. Prato: Istituto Regionale Programmazione Economica della Toscana (IRPET). Retrieved from: IRPET website.

[48] Google. (n.d.). Places API. Retrieved from Google Maps Platform.

shoe repair shops, repair cafés, and cleaning services. Rental providers offer textile rental services such as clothing and costume rental businesses. Recycling locations involve textile waste management and recycling, including textile collection bins and stores with take-back services.

This analysis is limited to consumer-oriented POIs, considering only locations accessible to the general public. Facilities primarily serving industrial or business purposes within the circular textile value chain, such as sorting facilities, are excluded. Furthermore, the study does not differentiate between specific textile-related products, such as shoes, carpets, clothing, or bags. Depending on the data source, a POI may be classified under multiple categories. For example, a vintage store offering repair workshops is categorised under both reuse and repair, while a collection bin supplying secondhand stores contributes to both reuse and recycling.

POI inventory

A total of 247 POIs were found for the Prato province, with 164 located within the city of Prato (see Table 1). Only one publicly available data source was found—an official list of collection points and bins for used clothing operated by *Alia Servizi Ambientali* in the province of Prato.[49] The remaining POIs were sourced from the Google Places API. The bottom-up data draws from the official list of textile waste collection points, including drop-off locations and bins, while the Google Places API provides additional POIs related to reuse and recycling.

	Reuse	Recycle	Repair	Rental	Total
Count	95	61	70	0	164

Table 1: Overview of the bottom-up collected points of interest within the city of Prato.

4.1.2 Results

Accessibility

The analysis reveals distinct spatial patterns in the accessibility of circular textile services across the Prato province. Most neighbourhoods have populations between 10,000 and 20,000, except for three central neighbourhoods with more than 30,000 residents. Given a maximum driving time of ten minutes (Figure 1), these three central neighbourhoods have more POIs for all three services (reuse, recycle, repair), but not significantly. Recycle POIs are more evenly distributed, while reuse POIs are slightly more concentrated in the central areas. There are fewer repair POIs overall compared to the other two services in the territory.

When considering a 15-minute walking time (Figure 2), accessibility patterns shift. Only the most central neighbourhoods have significant access to POIs. The differences in accessibility between neighbourhoods are more apparent when walking. Given a

[49] Alia Servizi Ambientali. (n.d.). Punti di raccolta oli alimentari esausti e abiti usati. Retrieved from: Alia website.

maximum driving time of ten minutes, the accessibility expands significantly, allowing peripheral neighbourhoods to access services that are mostly concentrated in the centre of the territory.

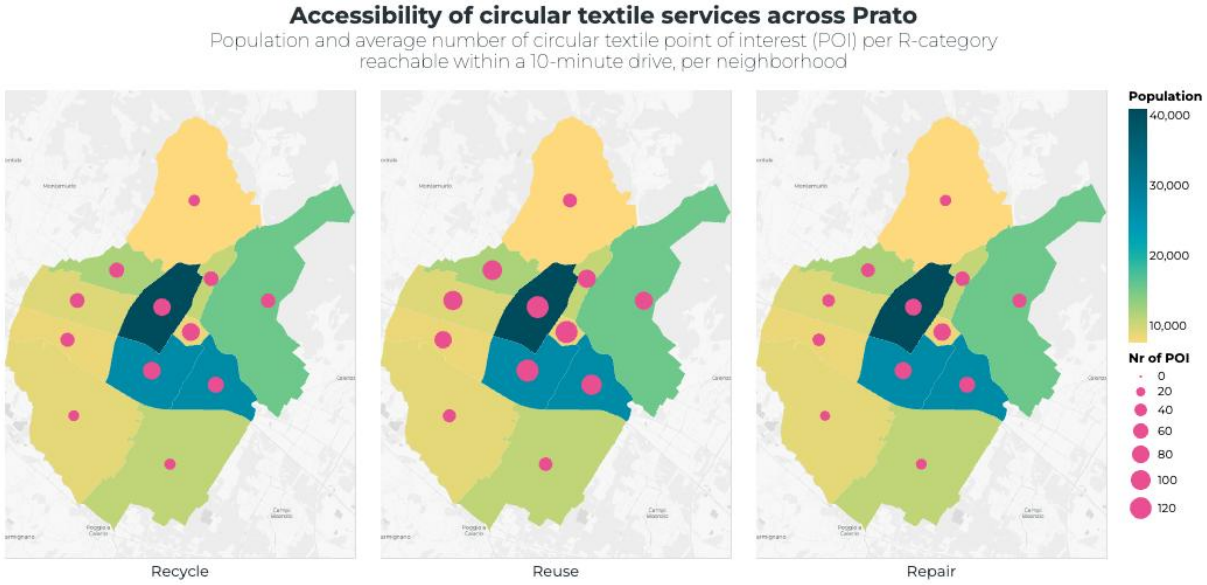


Figure 1: The accessibility maps illustrate the average number of recycle, reuse, and repair (3R) POIs reachable within a 10-minute drive for residents in each Prato neighbourhood. Larger bubbles indicate greater accessibility, while darker shades represent higher population density. The plot compares population and accessibility levels across neighbourhoods to highlight spatial patterns or disparities.

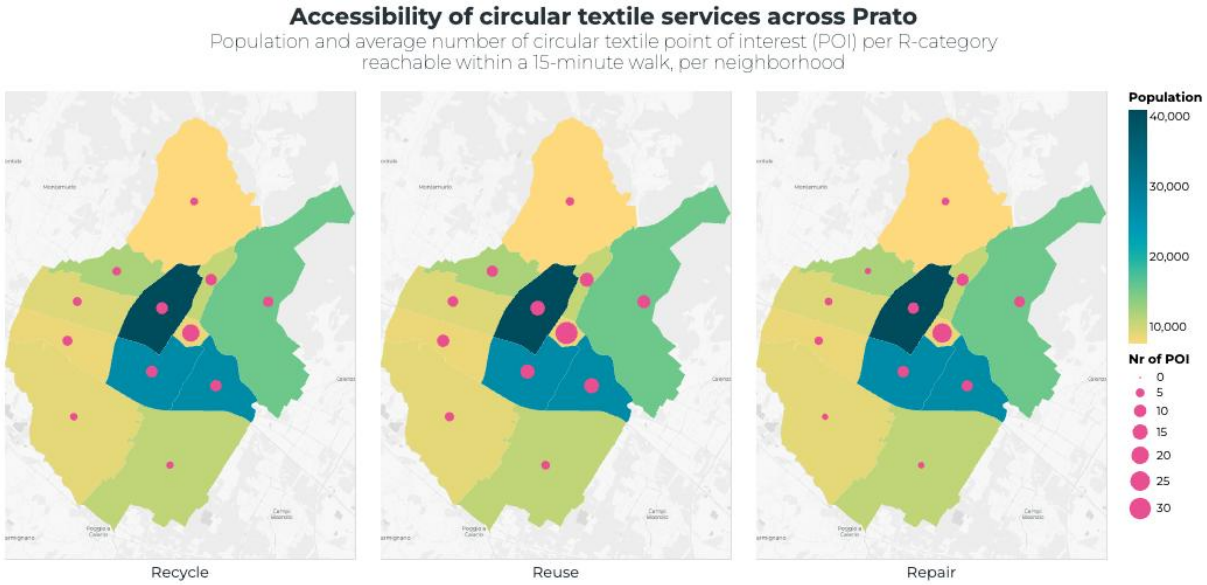


Figure 2: The accessibility maps illustrate the average number of recycle, reuse, and repair (3R) POIs reachable within a 15-minute walk for residents in each Prato neighbourhood. Larger bubbles indicate greater accessibility, while darker shades represent higher population density. The plot compares population and accessibility levels across neighbourhoods to highlight spatial patterns or disparities.

Travel time

The analysis shows that 50% of Prato's population can reach at least one POI within seven minutes and 27 seconds on foot or one minute and 38 seconds by car (Figure 3). However, accessibility varies, with some residents facing significantly longer travel times—the longest distance to the nearest POI is 27 minutes by walking and six minutes by driving.

A significant 96% of the population (179,275 people) can reach POIs from all categories within a 15-minute walk, whereas 100% of the population (187,560 people) can access all three categories within a ten-minute drive.

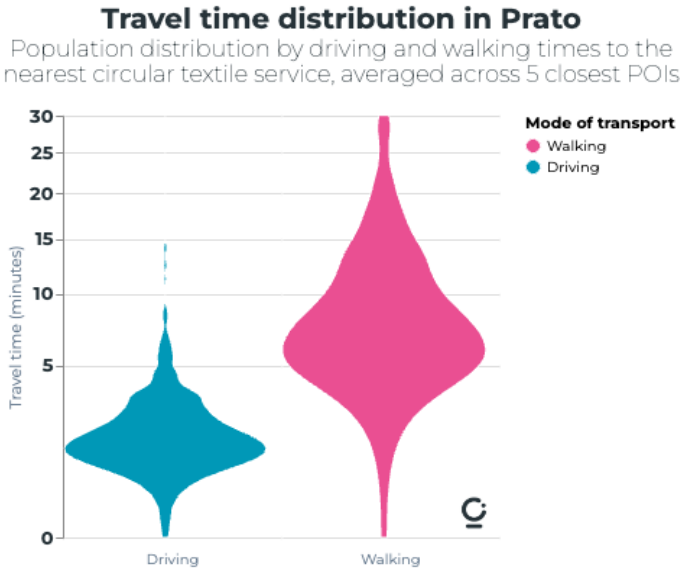


Figure 3: The chart shows the distribution of travel times for Prato's population to reach a circular textile POI, by driving (blue) and walking (pink).

Socioeconomic factors

The analysis suggests that average household income is not a key determinant of accessibility to circular economy services in Prato. While some lower-income areas, particularly those in the centre, have access to a higher number of POIs compared to higher-income neighbourhoods, some of the highest-income areas show better accessibility than middle-income ones (Figure 4). Insights from previous maps indicate that the distribution of circular textile services may be more strongly influenced by population density rather than household income.

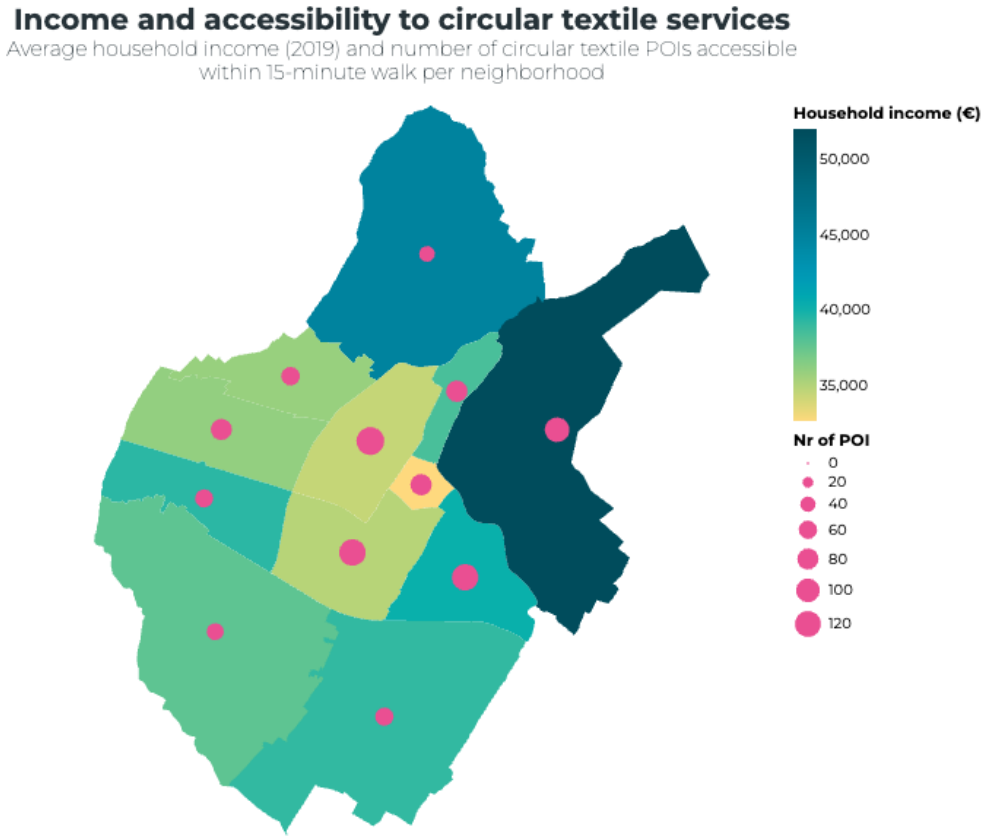


Figure 4: Choropleth and density bubble map showing that lighter shades (lower income) and darker shades (higher income) have similar access. Accessibility is more influenced by population density than socioeconomic factors.

4.2 Material Flow Analysis

4.2.1. Methodology

In Prato, the life cycle of textiles unfolds through five interconnected stages: fibre production, textile manufacturing, distribution and retail, use and repair, and waste management (including recycling). To provide a detailed view of these stages, a Material Flow Analysis (MFA) was conducted, offering valuable insights into the region's textile flows in 2022. The analysis focused on clothing and footwear, home textiles, and technical textiles. Data on fibre production, textile manufacturing, and repair activities were retrieved using NACE classification codes (see the Methodology Document for details).

Official data on fibre production in the region is unavailable, so estimates were made using Italy's fibre production figures from Eurostat's Prodcom dataset,[50] along with employment data for Prato and Italy.[51]

The textile manufacturing stage includes local production, imports, and exports. Regional data on textile manufacturing by mass is not available, so national production data was downscaled to the regional level based on employment in the relevant NACE sectors (13, 14,

[50] Sold production, exports and imports. (n.d.). Eurostat. Retrieved from: ec.europa.eu

[51] ISTAT. (n.d.). Unità locali e addetti. Retrieved from: dati.istat.it/

and 15) in both Prato and Italy. Trade data, available in monetary terms, was used to estimate textile volumes by converting monetary values to mass based on the Prodcom dataset.[52]

To estimate textile consumption in Italy, we used the Prodcom dataset, which provides production data in various units (tonnes, kilograms, number of items, and square metres). For items and square metres, average weights per garment were used from Van Duijn et al. (2022),[53] and the weight for fabrics was retrieved from Huygens et al. (2023) .[54] The consumption of textiles is calculated as:

$$Use = Import_{fin.prod} + Production_{fin.prod} - Exports_{fin.prod}$$

For Prato, the average household expenditure on clothing and footwear is 22% lower than the national average.[55] This adjustment was applied to national consumption figures to estimate Prato's textile consumption.

Data on second-hand clothing from Prato Comune, including the number of second-hand shops and average sales from one shop, was used to estimate the annual tonnes of second-hand clothing sold. Similarly, the number of repair shops and the average number of repairs per year (proportioned by Prato Comune) were used to estimate the tonnes of textiles repaired annually.

The waste management stage includes both pre-consumer and post-consumer textile waste. While official statistics on post-consumer waste in the region are available,[56] Prato imports post-consumer waste for sorting, and there is no official data on the amount of textile waste traded. However, data shared by Prato Comune, based on Corertex, enabled estimates of waste volumes and treatment rates.

Pre-consumer textile waste is not captured regionally. Using the Fiber Conversion Methodology,[57] standardised coefficients were applied to estimate total waste generation. While the volumes of this waste are assumed to be sorted, the treatment process remains unknown.

4.2.2. Results

Fibre production in Prato amounts to 25.4 thousand tonnes annually, with 15.8 thousand tonnes being exported, supporting a strong regional textile industry. Manufacturing is significant, with 112.9 thousand tonnes of finished textiles produced each year, of which 72.6 thousand tonnes are exported.

[52] ISTAT. (n.d.). Unità locali e addetti. Retrieved from: dati.istat.it/

[53] Van Duijn, A., Papú, N., Bakowska, O., Huang, Q., Akerboom, M., Rademan K., Vellanki, D. (2022). Sorting for Circularity Europe. Retrieved from: Fashion for Good website

[54] Huygens, D., Foschi, J., Caro, D., Caldeira, C., Faraca, G., Foster, G., Solis, M., Marschinski, R., Napolano, L., Fruergaard Astrup, T. and Tonini, D., Techno-scientific assessment of the management options for used and waste textiles in the European Union. Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/6292, JRC134586.

[55] http://dati.istat.it/Index.aspx?QueryId=17161&lang=en

[56] Centro Nazionale per il ciclo dei rifiuti-ISPRA. (n.d.). ISPRA :: Catasto Nazionale Rifiuti. Isprambiente.It. Retrieved from catasto-rifiuti.isprambiente.it/

[57] Textile Exchange. (2019). Fiber Conversion Methodology. Retrieved from: textileexchange.org

Textile consumption per capita in Prato is relatively low at 16.5 kilograms per person, compared to the Italian average of 21.2 kilograms per person and the EU average of 23 kilograms per person.[58] Total consumption in Prato results in 4.2 thousand tonnes. The difference between Prato and Italy is based on consumption expenditure, where the Tuscan region consumes 22% less clothing and footwear. Repair activities are minimal, with only 5.13 tonnes of textiles repaired annually. Post-consumer textile collection within Prato amounts to 1.2 thousand tonnes per year, while an additional 48.8 thousand tonnes of post-consumer textiles are imported. Pre-consumer textile volumes are also substantial, totalling 24.4 thousand tonnes.

Treatment pathways for post-consumer textiles vary: 0.8% is reused locally, 64.2% is exported for reuse, 30% is recycled, and 5% is landfilled. No data is available on the treatment of pre-consumer textiles. Each year, 32.5 thousand tonnes of textiles are sorted for reuse, with nearly all of them being exported. However, once exported, their final destination is not monitored or controlled by the region that sends them.

Local textile reuse accounts for 400 tonnes annually, accounting for 10% of total consumption, highlighting the region's reliance on international markets to give textiles a second life.

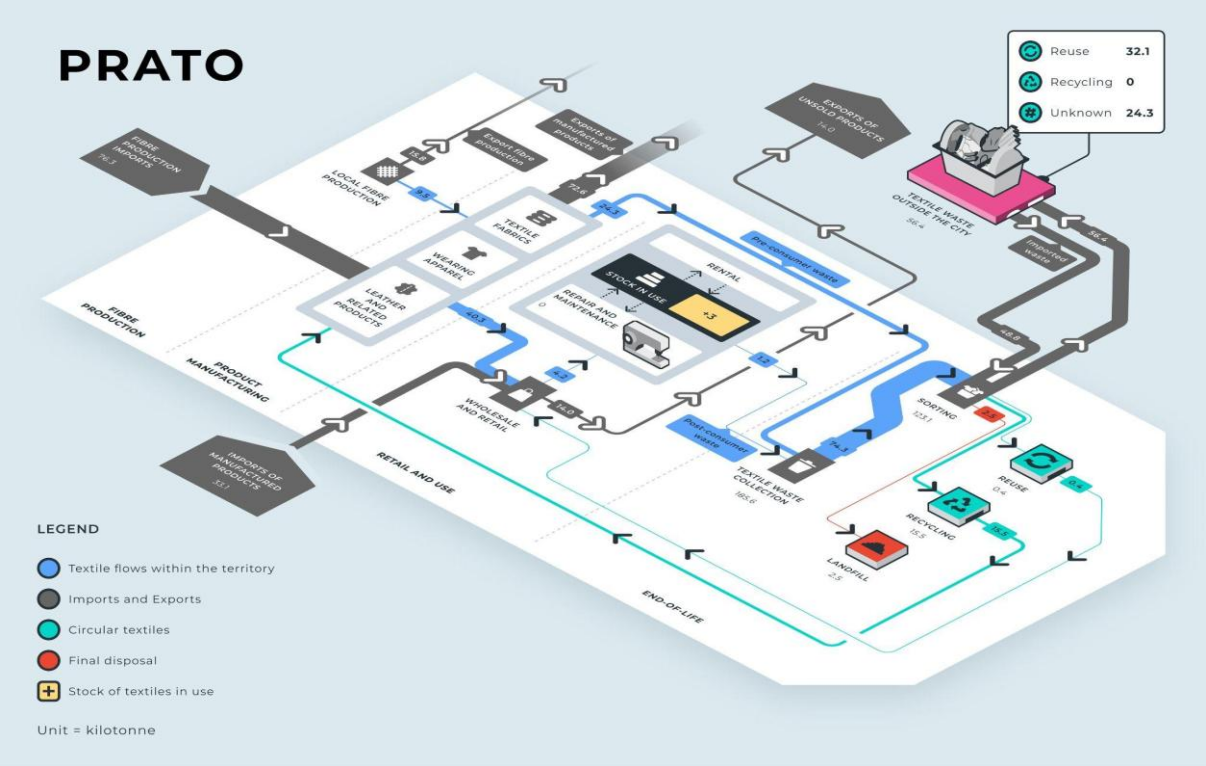


Figure 5: Material Flow Assessment results

[58] European Environment Agency (2022). EU-27 apparent consumption of clothing, footwear and household textiles. Retrieved from EEA website. Value based on the same NACE codes considered in this analysis, further explained in the Methodology document

4.3 Employment baseline

4.3.1 Methodology

Both full-time equivalent (FTE) and 'job' counts are used in this analysis, but they should not be interpreted as identical measures. Where specific FTE figures were not accessible, employment data was referenced more generally under the term 'jobs'. Local authority statistics from Prato for 2022 provided figures for manufacturing, distribution, retail, and parts of the repair sector. In cases where direct data was unavailable, estimates were derived from contextual knowledge and interviews. These informed job numbers in the reuse and rental sectors, as well as parts of the repair sector.

For collection, sorting, and recycling, employment data was sourced from Corertex, as no alternative datasets were available. However, this data has not been verified by the municipality of Prato. When reporting 'zero jobs', this does not indicate a complete absence of employment but rather a lack of consistently identifiable data sources. Further details on data limitations and methodology are provided in the following section. The data presented covers the period between 2022 and 2024.

4.3.2 Results

An estimated 46,371 people work in the textile value chain in Prato, spanning fibre production, textile manufacturing, distribution and retail, use and repair, and waste management activities. Each stage of the value chain varies in employment levels, with some sectors lacking available data or showing low reliability due to limited reporting.

Fibre production

Employment in production could not be quantified, as fibre production in Prato is integrated with broader manufacturing activities, making it difficult to isolate specific job numbers.

Textile manufacturing

Manufacturing represents the largest share of employment in the textile value chain, with 40,032 jobs recorded at the provincial level in 2022.[59] This includes 14,883 jobs in textile manufacturing, 24,432 in the production of wearing apparel, and 717 in leather, leather products, and footwear manufacturing. These figures are fairly aligned with existing literature. Indeed, one source underlines that the Prato textile district covers 13 municipalities (including Prato city), and employs a total of 46,166 people in Textile and Clothing manufacturing.[60]

[59] Dati Istat http://dati.istat.it/OECDStat_Metadata/ShowMetadata.ashx?Dataset=DICA_ASIAULP&Coords=%5bD1%5d&ShowOnWeb=true&Lang=it (2022)

[60] Coppola, M.C., Giorgi, D., Stasi, Renato. & Tufarelli, M. (2022). Sustainability in the Prato Textile District: Vanguard and Tradition. Pages on Arts and Design, 15(22), 87-109. Retrieved from: Sustainability in the Prato Textile District: Vanguard and Tradition

Distribution and retail

The distribution and retail sector accounted for 5,189 jobs, with 3,768 positions in wholesale and 1,421 in textile retail.[61]

Second-hand retail

Employment in the second-hand retail sector was not available at the city level, but estimates based on store numbers indicate approximately 67 jobs. In 2024, Prato had 20 second-hand textile shops, with an assumed average of 1.5 employees per store. However, data from three stores suggested an average of 3.33 employees per shop. Individual store reports varied, with one store employing six people (three men and three women, all under 50) and another employing four people (two women aged 40 and 42, and two men aged 21 and 30). More broadly in Italy, second-hand textile shops employ an average of five staff members, with a gender distribution of 60% women and 40% men, and an average employee age of 33 years.

Use and repair

Rental

Rental activities employed an estimated five people, with no direct employment data available. Instead, figures were derived from the three rental shops identified by the municipality in 2024, each assumed to employ an average of 1.5 FTE.

Repair, upcycling and maintenance

Repair and maintenance activities accounted for an estimated 478 jobs. As with other labour datasets in this research, official statistics provided employment figures for certain repair activities, such as footwear and leather goods (NACE code 9523) and washing and dry-cleaning services (NACE code 9601), but did not specify jobs related solely to textile repair. The repair of footwear and leather goods employed 16 people in 2022,[62] while washing and dry-cleaning services accounted for 432 jobs in the same year.[63] To estimate employment specifically in textile repair, the research team relied on the number of active repair shops in Prato. In 2024, there were 15 repair shops in the city, with an assumed average of two employees per shop. This method resulted in an estimated 30 jobs in textile repair, based on sector-specific knowledge and available business data.

Waste management

Collection and sorting

Collection, sorting, and recycling activities employed an estimated 600 people, based on figures reported by Corertex, a consortium working on textile waste management in Prato.

[61] Dati Istat http://dati.istat.it/OECDStat_Metadata/ShowMetadata.ashx?Dataset=DICA_ASIAULP&Coords=%5bD1%5d&ShowOnWeb=true&Lang=it (2022)

[62] I stat (2022) http://dati.istat.it/Index.aspx?DataSetCode=DICA_ASIAULP#

[63] I stat (2022) http://dati.istat.it/Index.aspx?DataSetCode=DICA_ASIAULP#

However, these figures could not be verified by the municipality or the research team.[64] It is likely that the 600 employees handle a mix of municipal and industrial textile waste, including imported materials. The employment numbers for recycling are taken to be included in this overarching figure of 600 workers.

Landfill and incineration

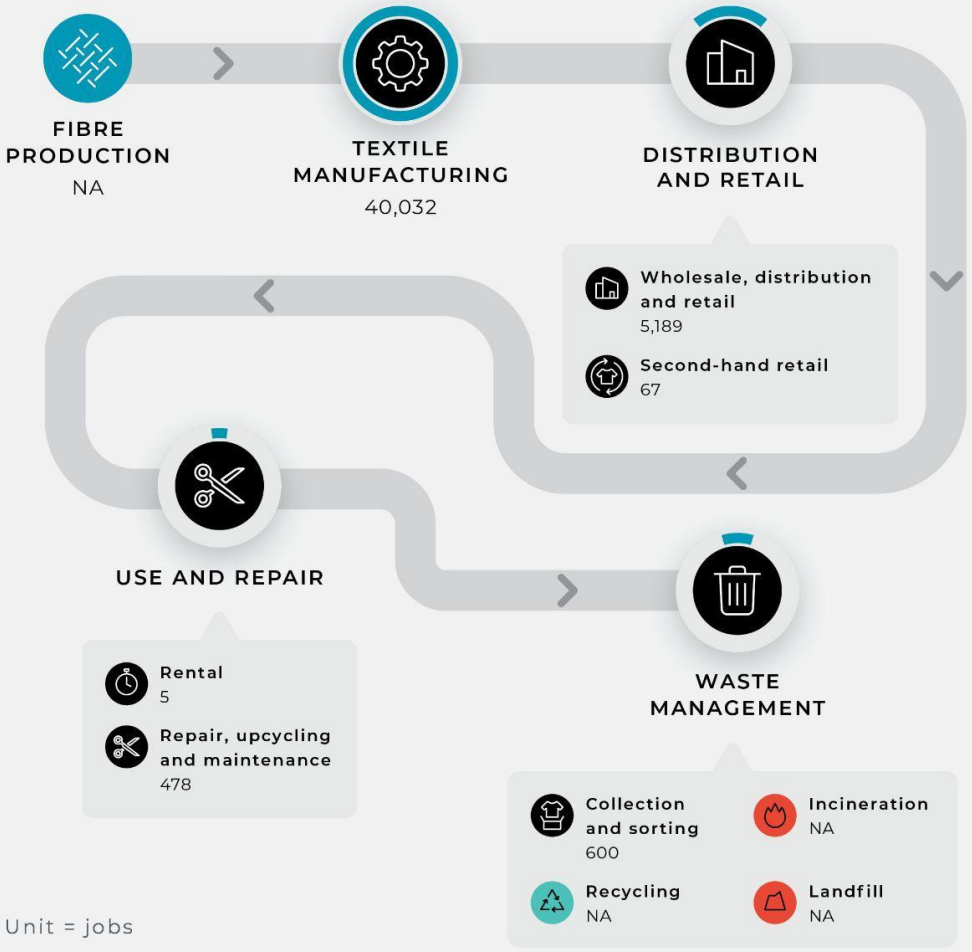
No employment data was available for landfill and incineration activities in Prato, making it impossible to estimate the number of jobs in this sector.

[64] Coreretex website

OVERVIEW OF **EMPLOYMENT** IN THE **TEXTILE SECTOR** IN PRATO (2022/2024)

This infrographic presents the number of employed people in the textile sector in Prato. Some activities could not be retrieved. A value of NA does not indicate the absence of jobs but rather that the data was unavailable. Data sources vary, so please refer to the methodological section in the main text for further details.

TOTAL
46,371



4.4 Consumer behaviour

4.4.1 Methodology

An investigation into consumer behaviour in Prato Berlin was undertaken, employing a multi-faceted approach to data collection to gain a comprehensive understanding of consumer behaviour regarding circular textiles in Prato. A diverse group of 10 participants, including consumers, business representatives, and local organisations, took part in the discussions, ensuring a broad spectrum of perspectives. A combination of qualitative and quantitative methods was used to capture insights. Online focus group discussions were conducted via Google Meet, allowing for interactive dialogue and knowledge-sharing among participants. To complement these discussions, Mentimeter was used for real-time polling, providing structured, data-driven insights into consumer attitudes, behaviours, and preferences. The focus groups explored three key themes: purchase drivers (price, brand loyalty, and sustainability); awareness and barriers (understanding of circular solutions and obstacles to adoption); and opportunities for circular textiles.

An initial assessment was conducted to map existing consumer behaviour trends in Prato and Italy. Building on these insights, an iterative process guided the focus group design and execution.[65] Key findings from this initial assessment included:

- **Financial constraints shape consumption:** Socioeconomic factors heavily influence willingness to pay, with financial limitations cited as the primary reason for reducing clothing consumption.[66]
- **High clothing expenditures:** In 2020, Italy's per capita clothing consumption stood at €710, making it the fourth highest in Europe.[67]
- **Market dominance of fast fashion:** Global brands such as Nike, Adidas, Zara, and H&M account for the majority of clothing purchases in Italy.[68]
- **Mixed attitudes toward sustainable fashion:** While consumers express positive views on sustainable clothing, purchasing decisions remain primarily driven by quality, price, and comfort.[69]
- **Familiarity increases adoption:** Several studies indicate that consumers who are more familiar with sustainable clothing are more likely to purchase it.[70]

[65] The initial approach included a survey on consumer behaviour in order to gather insights directly from consumers, in light of time and resource constraints a focus group was selected as a sufficient method to gather consumer insights.

[66] Italy Apparel Consumer Insights – Who Shops, What do they Shop, How do they Shop and Why do they Shop

[67] Which European countries offer the most opportunities for recycled fashion?

[68] Italy Apparel Consumer Insights – Who Shops, What do they Shop, How do they Shop and Why do they Shop

[69] Sustainable Fashion Consumption

[70] https://www.researchgate.net/publication/363892677_Investigating_the_antecedents_of_consumer_behavioral_intention_for_sustainable_fashion_products_Evidence_from_a_large_survey_of_Italian_consumers

- **Preference for certifications over behavioural shifts:** Italians value sustainability certifications but show limited interest in second-hand shopping or reducing overall clothing consumption.[71]

4.4.2 Insights and key results

Consumer motivations and profiles

Consumer purchasing decisions in Prato are primarily driven by price and quality, with affordability remaining a key factor across all demographics. Fashion trends and personal aesthetics play a significant role, particularly among younger consumers who are heavily influenced by social media and peer opinions. However, cultural stigma continues to shape purchasing behaviours, especially regarding second-hand clothing. This stigma is particularly strong for symbolic or formal garments, such as wedding dresses.

Awareness of circular solutions and barriers

While consumers in Prato generally have a good awareness of the environmental impacts of textile production, their knowledge of circular solutions—particularly repair and reuse options—remains limited. Donation centres and second-hand shops are well recognised, but awareness of alternative circular practices, such as repair workshops and upcycling initiatives, is significantly lower. This gap suggests that while sustainability is acknowledged, practical engagement with circular alternatives is still developing.

Several key barriers prevent the wider adoption of circular textile solutions. Cost remains a significant obstacle, as circular products and services are often perceived as more expensive than conventional options. Accessibility is another challenge, with repair services being scarce outside central urban areas, limiting consumer engagement. Additionally, trust issues persist, with consumers expressing scepticism about the transparency and quality of circular offerings. Social biases against second-hand garments remain deeply rooted, particularly in traditional and formal contexts. This reluctance to embrace pre-owned clothing presents a challenge for circular fashion initiatives, as cultural perceptions often outweigh environmental considerations in purchasing decisions. Addressing these ingrained attitudes will be crucial in fostering a shift towards more circular textile consumption in Prato.

Opportunities for circular textiles

The focus group in Prato identified several specific opportunities to promote circular textile practices within the city. Key suggestions included the introduction of mobile collection points, which would make the textile collection more accessible to local communities. Creative repair workshops were also proposed, allowing consumers to engage in hands-on activities to upcycle or repurpose old garments, fostering a deeper connection with circular practices. To address the stigma surrounding second-hand fashion, campaigns could be launched to normalise and promote its economic and environmental benefits, shifting public perception. These initiatives could be supported by fostering partnerships between

[71] https://philarchive.org/archive/NGUEICv1

producers and distributors to achieve economies of scale and allow circular products to become more competitive, making sustainable choices more accessible to a wider audience.

General solutions highlighted across the focus groups emphasised the importance of expanding circular infrastructure and networks. The promotion of circular fashion, alongside economic incentives, was seen as essential for encouraging consumer participation. Expanding post-consumer textile collection networks would also enable more efficient recycling and reuse, addressing the logistical challenges associated with textile waste. Creative reuse workshops and clothing swap initiatives were recognised as valuable tools for engaging consumers and promoting sustainable consumption habits.

Participants stressed that several cross-cutting factors are crucial for the success of circular solutions. These include promoting cost-effective circular options, improving trust and transparency around sustainability claims, raising awareness, and fostering greater community involvement. By addressing these factors, circular practices could become more integrated into consumers' daily lives, ultimately driving greater adoption and reducing textile consumption across Prato.

4.5 Environmental assessment

4.5.1 Methodology

Manufacturing

This chapter estimates the environmental effects of Prato's textiles flows. Using a life cycle assessment (LCA) approach, the method builds on the results of the MFA, connecting the identified quantities of material flows to their associated environmental impacts. The goal of this assessment is to highlight key priority impact areas within the textiles value chain, as well as laying the foundation for estimating the impact reductions as a consequence of the potential circular pilot solutions. These pilots are co-designed, tested and evaluated per territory in WP3.

The proposed methodology for this baseline environmental assessment of the current textiles flows in each region consists of the following steps (see Figure 6): (1) desk research on the environmental impacts of textiles (2) identifying relevant MFA data (selecting the textile flows in scope for the assessment) (3) approximate the composition of the textile flows (4) apply the LCA method to estimate the textile flows' relevant impacts (5) present quantitative estimations on the environmental effect of the to-be-introduced pilots.

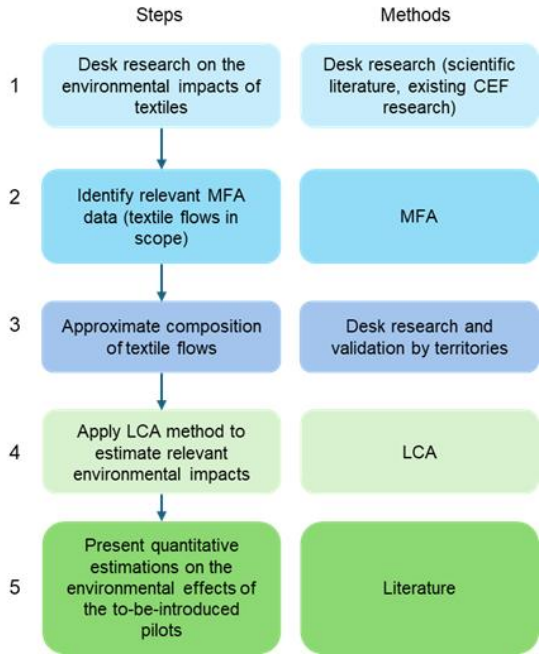


Figure 6: Description of the methodology steps for the baseline environmental assessment

Step 1: An introduction to the environmental impact of textiles

The global textile industry is largely linear: of the 3.25 billion tonnes of textile materials consumed each year, over 99% come from virgin sources, making it only 0.3% circular (Circle Economy, 2024). The textile industry also has a high environmental impact, in particular with high demand for water, land and energy required to produce fibres and textile products: around 4-6 % of the EU's environmental footprint across a range of impact categories is caused by the consumption of textiles, with the large majority of those impacts occurring elsewhere in the world (Köhler et al., 2021). Key impact categories to look at when assessing the environmental impact of textiles are global warming, water consumption, land use change, water and air pollution, and the release of microplastics into terrestrial and aquatic environments.

The textile life cycle stages - not including the use phase - with the highest environmental footprint are typically material extraction, processing, and product manufacturing (Circle Economy, 2024). At the same time, textiles' end-of-life stage is also problematic, as post-consumer textile waste is still largely characterised by incineration and landfilling instead of reuse, repair or recycling pathways. In fact, a large share of used textiles separately collected in the EU and sorted for recycling ends up being traded and exported to Africa and Asia with a highly uncertain fate (EEA, 2024).

Textiles are a heterogeneous group of materials. Clothing and household textile items are composed of a variety of materials, each with highly distinct origins and manufacturing processes, and therefore different environmental impacts. The origin of textile fiber can be natural (cotton, wool, linen, silk), synthetic (polyester, nylon), or semi-synthetic (rayon), with many textiles being composed of blends between different natural and synthetic fibers.

Additives and colouring agents cause additional material complexity. The textile industry is increasingly using fossil-fuel-derived synthetic fibres like polyester, currently making up 63% of the raw materials used in textile production (Circle Economy, 2024).

There are multiple scientific methods to calculate materials' environmental impacts. One of the most widely used is life cycle assessment (LCA), which allows to evaluate the environmental impacts of a product, process, or service throughout its life cycle, from "cradle to grave" (i.e., from raw material extraction through manufacturing, use, and end-of-life disposal or recycling). The LCA process is typically carried out by (1) setting the goal and scope, (2) inventorying data on resource inputs (energy, materials) at each stage of product life cycle, (3) assessing the product's impacts, often expressing them in midpoint indicators[72] such as global warming potential (GWP), measured in CO_2 equivalents, and (4) interpreting the results.

LCA results are often complex to interpret, as most conventional impact assessment methods report on many midpoint impact categories[73]. To produce results that are understandable and in line with policy makers' goals, we propose to select a limited number of impact categories, based on which impact categories are most relevant to the domain of focus. Several existing methodologies and references are available to do so (see Higg MSI tool or Quantis report), and previous work by Circle Economy will be used to align the selected impact areas with (CGR Textiles, CGR Quebec). The selected impact categories on which we present the general impact results for the material types are:

- **Global Warming Potential, expressed in kg CO2e/kg material**
    - The industry contributes almost 3.5% of global greenhouse gas (GHG) emissions linked to climate change, with material production, including fabric and trim manufacturing and finishing, accounting for 55% of the industry's GHG emissions, largely due to energy-intensive wet processing.
- **Energy Use, expressed in non-renewable energy consumption MJ/kg material**
    - As expressed above, various steps of the textiles value chain, in particular fibre production, and product manufacturing and finishing are quite energy-intensive, and to a large degree still rely on fossil energy sources.
- **Water consumption, in m3 water/kg material**
    - Additionally, the industry accounts for 3.5% of the total water scarcity impact caused by all global manufacturing activities, often operating in regions already facing water shortages. Factors such as geographical constraints, population growth, and competing industrial and domestic demands worsen water scarcity. The dyeing and finishing stages of the textile value

[72] Midpoint indicators measure environmental impacts in specific categories, such as climate change (GWP), ozone depletion, resource depletion, and others. Midpoint indicators are useful for assessing the relative contribution of different stages of a product's life cycle to specific environmental issues. The midpoint method looks at the environmental impact earlier along the cause-effect chain before the endpoint is reached. For example, the midpoint method might look at the global warming impact, which later on may relate to different endpoint impacts, such as damage to human health or ecosystems.

[73] The ReCiPe midpoint method, for instance, presents results for 18 midpoint categories.

chain are especially water-intensive, consuming approximately 93 billion cubic metres of water annually (Circle Economy, 2024).

- **Land use change, m2a crop/kg material, and microplastics emissions**
  - Land use change concerns the clearing of native vegetation to establish new agricultural grounds, for example for the production of cotton. Such changes lead to various interlinked environmental issues, such as increased GHG emissions through soil degradation and biodiversity loss. Cotton is also linked to deforestation (Solidaridad, 2023).
  - For synthetic materials, land use change issues are less material, but emissions from microplastics become relevant. While research to include quantifiable midpoint-indicator results for microplastics in the LCA method is very new (TNO, 2024), it is clear that the textile industry significantly contributes to microplastic pollution through materials and embellishments used in garments, such as prints, coatings, buttons, and glitter. Synthetic plastics, including those in textiles, take decades to degrade, particularly in marine environments (Circle Economy, 2024).
- **Marine and freshwater eutrophication, in kg P and N/kg material**
  - Textiles contribute to over 5% of marine eutrophication and over 4% of global freshwater eutrophication, primarily due to fertilizer runoff from cotton farming and the chemicals used in dyeing processes (Circle Economy, 2024).

The impact factors for 1 kg of each fibre type for the different impact categories mentioned above were retrieved using the LCA software SimaPro and the ecoinvent database. For all impact indicators, the ReCiPe 2016 midpoint (H) was used, except Energy Use, for which the Cumulative Energy Demand V1.11 method was chosen. The impact factors are summarised in Table 2 below.

Impact Categories per kg of fibre	Global Warming Potential (kg CO2e/kg)	Energy Use (non-renewable, fossil, MJ/kg)	Water Consumption (m3/kg)	Land Use (m2a crop eq/kg)	Freshwater eutrophication (kg P eq/kg)	Marine eutrophication (kg N eq/kg)
Cotton	12	111	5.52	7.32	0.0093	0.0534
Polyester	5.78	104	0.0389	0.201	0.002	0.000276
Polyamide	9.82	114	0.069	0.00199	0.000294	0.000313
Wool	52.2	N/A	0.851	58.2	0.0126	0.0443
Polypropylene	3.15	87.2	0.011	0.0371	0.000711	0.0000615
Viscose	3.33	36.4	0.0636	0.996	0.00132	0.000123
Acrylic	3.73	81.2	0.0469	0.0342	0.00111	0.00315

Other fibres	N/A	N/A	N/A	N/A	N/A	N/A
Non-textile material	N/A	N/A	N/A	N/A	N/A	N/A

Table 2: Summary of environmental impact factors per kg of textile fibre, per type of textile fibre

Step 2: Identifying the relevant MFA data

The collected MFA data contains estimated textile flows for each region. Several stages of the textile value chain are included, from fibre production, textile manufacturing, distribution, and retail to repair/rental/secondhand and, finally, waste management. The granularity of this MFA data—i.e., its availability for different value chain stages—allows quantifying textile flows that are most relevant to Prato. To combine MFA results with the life cycle impact assessment, we decided to use the post-consumer stage as a reference value chain step, therefore the baseline environmental impact factors are multiplied by the total amount of textile waste collected (in ktons), which in Prato is a total of 74.3 ktons (of which 24.3 kt come from industrial processes, and 50 kt are categorised as post-consumer waste, although the vast majority of this is actually imported from other regions).

Step 3: Approximate composition of textile flows

Virtually no country-level information is available on the composition of textiles. Often, estimations are complicated by different definitions and scopes. Several reports and studies conducted in recent years present different estimations of the composition of textiles in Europe, distinguishing between production, import, and exports of fibres, yarn and textile products.A common finding is that there seems to be a relatively large uncertainty with regards to the exact composition of textiles at these stages (Köhler et al. 2021),[74] possibly due to the fact that textile products are made of blends of different fibres. In recent research by Circle Economy for the JRC[75], 18 tonnes of textile waste across 3 countries (Czech Republic, Romania and Italy) were sampled, it was found that 28.7% consisted of "other blends", with many other composition categories also consisting of textile blends (such as 80-99% Cotton and 40-95% Polyester).

Despite these limitations, the decision was made to use recent data presented in the JRC report by Huygens et al. 2023, as it appeared to be the most robust fibre composition estimation available at the time of the assessment, and it was required to establish a baseline composition estimation. The composition breakdown and absolute figures for Prato are summarised in Table 3 below and cover over 82% of all post-consumer textile

[74] More than 50 % of production, imports and exports of fabrics are undefined with respect to fibre composition.

[75] BAKOWSKA, O., MORA, I., WALSH, S., VAN DUIJN, H., NOVAK, M., CHERUBINI, G., JOSHI, R., MORBIATO, A., VISILEANU, E., VESELÁ, A., RYŠAVÁ, E. and HOLICKY, M., Fate and Composition of Textile Waste from Italy, the Czech Republic and Romania, HUYGENS, D. editor(s), Publications Office of the European Union, Luxembourg, 2025, https://data.europa.eu/doi/10.2760/3332076, JRC141441.

waste collected (in mass), and at least 90% of all fibre types used in the production of textile products used in the EU.[76]

Fiber type	Fibre composition of new products	Fibre composition of post-consumer waste	Breakdown of textile waste by type of fibre in Prato (in tonnes)
Cotton	33.3%	33.7%	24.9
Polyester	29.3%	29%	21.6
Polyamide	7.3%	7.1%	5.3
Wool	3.9%	3.9%	2.9
Polypropylene	3.1%	3.2%	2.4
Viscose	3.1%	3.1%	2.3
Acrylic	2.8%	2.7%	2.0
Other fibres	6%	5.9%	4.4
Non-textile material	11%	11.5%	8.4

Table 3: Summary of the fibre composition in post-consumer textile waste in Prato

4.5.2. Results

Step 4: Estimation of environmental impacts in Prato

To produce quantitative results, the MFA data (tons of textile flows) for post-consumer textile waste in Prato will be used as reference mass inputs to the LCIA, providing insights into the life-cycle impacts of the textile flows relevant to the End-of-Life stage. The reason for selecting this particular stage (instead of production, manufacturing, or textiles put on the market) is to be able to conduct some scenarios regarding different post-consumer textile treatments and fates (repair, reuse, recycling, etc.) at a later stage of the project.[77]

The preliminary results of the baseline environmental impact assessment of post-consumer textile flows in Prato are summarised in Table 4 below. Note that “other fibres” and “non-textile material” are missing more granular information in order to estimate their respective

[76] The fibre composition of pre and post-consumer textile waste in the EU is assumed to be representative for the fibre composition in Prato

[77] An example of this type of result: based on the literature review and LCA, it is estimated that the secondhand activities within the city of Prato would lead to a reduced consumption of new textiles products, reducing GHG emissions by X tons CO2e, water consumption by X m3, and land use by X m2a.

contribution to different environmental impacts, which is why they were left out of the baseline calculation.

Table 4: Baseline environmental impact assessment of post-consumer textile flows in Prato

Impact by fibre	Global Warming Potential (kt CO2e)	Energy Use (non-renewable, fossil, GWh)	Water Consumption (hm3)	Land Use (hectares crop eq)	Freshwater eutrophication (tonnes P eq)	Marine eutrophication (tonnes N eq)
Cotton	299.3	769.04	137.68	18257	231.96	1331.90
Polyester	125.0	624.57	0.84	435	43.24	5.97
Polyamide	52.3	168.59	0.37	1	1.57	1.67
Wool	151.3	NA	2.47	16865	36.51	128.37
Polypropylene	7.4	57.00	0.03	9	1.67	0.14
Viscose	7.7	23.29	0.15	229	3.04	0.28
Acrylic	7.6	45.80	0.10	7	2.25	6.40
Other fibres	NA	NA	NA	NA	NA	NA
Non-textile material	NA	NA	NA	NA	NA	NA
Total	**650.5**	**1688.29**	**141.62**	**35803**	**320.24**	**1474.72**

While the table above provides quantitative estimates of the total life-cycle footprint of different textile fibres, it is worth reviewing what the scientific literature tells us about key environmental hotspots across the textile value chain.

The largest sources of impact occur at the earlier stages of the value chain.[78] [79]

- **Raw material extraction and production** is a major impact hotspot, especially for natural fibres like cotton and wool. At this stage, the main environmental impacts occur in the impact categories of land use and water consumption, but also in the form of pollution like eutrophication due to irrigation runoff and pesticide use. For synthetic fibres, this stage is also an important contributor to fossil fuel extraction and energy consumption (with important associated greenhouse gas emissions) during polymerization processes.
- **Fibre production and garment manufacturing** stages are one the largest sources of impact. At these stages, energy and chemical-intensive processes like spinning and dyeing contribute substantially to GHG emissions, eutrophication. Some waste

[78] InvestNL. (2024). Towards a Dutch Circular Textile Industry: Exploring the common thread. Retrieved from: InvestNL website

[79] Gözet, B., & Wilts, H. (2022). The circular economy as a new narrative for the textile industry: An analysis of the textile value chain with a focus on Germany's transformation to a circular economy (Zukunftsimpuls no. 23). Wuppertal Institute

is already generated at these stages, in particular during garment manufacturing, and is accounted for as "pre-consumer" waste in the MFAs.

Wholesale and retail are responsible for a smaller fraction of the environmental impacts, which at these stages consist mainly of energy consumption and associated emissions, mainly from transport, or during operational phases of retail (e.g. electricity consumption in stores).

Although the **consumption and product-use phases** are outside of the scope of the environmental impact results show in in the table above, it must be noted that, over the long run, they can be responsible for a significant share of water and energy use due to washing/drying processes, and also for the release of microplastics for synthetic fabrics.[80] It is also a step of the value chain which is characterised by short lifespans induced by fast-fashion, which therefore contributes to amplifying the absolute environmental impact of textiles production (as product turnover cycles occur more rapidly, leading to more demand for new products).

Finally, it appears that the environmental impacts associated with **textile waste End-of-Life processes** are relatively small compared to the full life cycle impacts of textiles (largely influenced by production and manufacturing processes).[81] However, due to the large volumes of textile waste and poor End-of-Life management systems, it remains crucial to find circular solutions, like reuse or repair, that aim at minimising new consumption (and therefore, new production).[82] This is the focus of the following step (*Step 5*).

Step 5: Impact reductions as a result of the to-be-implemented circular solutions (pilots)

In a future phase of the project, we will utilise the baseline environmental impact results as reference to conduct a comprehensive Life Cycle Assessment (LCA)-based modelling of the estimated impact reductions that would result from the hypothetical changes in the value chain, tested in Prato's selected pilot project. This analysis will focus on either of the following R-strategies:

- **Refuse**: Refusing unnecessary consumption is arguably the most effective strategy for reducing environmental impacts. However, this approach involves complex considerations, such as Rebound effects (e.g. reduced consumption may lead to increased spending in other areas), or behavioral change challenges in shifting consumer habits.
- **Reuse**: Reuse strategies offer significant potential for impact reduction, but assessing their true additionality is challenging. As highlighted in a CE Delft

[80] Huygens, D., Foschi, J., Caro, D., Caldeira, C., Faraca, G., Foster, G., ... & Tonini, D. (2023). *Techno-scientific assessment of the management options for used and waste textiles in the European Union: JRC Science for Policy Report*. Publications Office of the European Union.

[81] InvestNL. (2024). Towards a Dutch Circular Textile Industry: Exploring the common thread. Retrieved from: InvestNL website

[82] EuRIC (2023). LCA-based assessment of the management of European used textiles. Retrieved from: EuRIC website

report:[83] "It is very uncertain how much less new textiles consumers will buy if they buy more second-hand.

- **Repair**: Extending product lifespans through repair can substantially reduce environmental impacts by delaying the need for new product manufacturing
- (Optional) **Recycling and End-of-Life Impacts**: While not a primary focus of the pilots, our analysis may touch upon recycling and end-of-life strategies. For instance, we will consider how these approaches can help avoid high-impact disposal methods like incineration, potentially leading to significant environmental benefits.

Work Package 3 will aim to provide quantitative assessments and detailed analyses of these strategies, offering valuable insights into their potential for reducing environmental impacts across various product lifecycles.

5. Key findings and recommendations

5.1 Summary of key findings and recommendations

1. The textile landscape in Prato

Prato is globally recognised for its leading innovation in the mechanical recycling of wool, positioning the city as a key player in the circular textile economy. The textile district of Prato represents approximately 3% of European textile production and has the potential to inspire other European regions and sectors. However, this extensive heritage also brings challenges, particularly in ensuring traceability and transparency within the recycling value chain. Despite its pioneering role, Prato currently faces gaps in tracking recycled materials, which hinders the ability to fully leverage the environmental and job creation benefits of circular ecosystems.

Recommendations:

- Establish a fully traceable hub for recycled fibres in Prato to create a pioneering global benchmark in traceability and circularity by backing up recycled material claims with reliable data and fostering stakeholder dialogue.
- Stress the importance of monitoring and quantifying pre and post-consumer textile waste generation, imports, and exports.
- Conduct detailed mapping of waste composition available, possibly down to facility-level analyses to identify material composition, volumes and prices of post-consumer and post-industrial waste available and its current destinations to understand in detail current bottlenecks, cost and revenue drivers and opportunities.
- Provide tailored coaching and awareness-raising programmes to help local businesses transition to circular services and adopt sustainable materials at scale,

[83] https://open.overheid.nl/documenten/ronl-e02e486cdb962a2280987b7f5456c0ab94c4b3da/pdf

while maintaining or increasing competitiveness.
- Support and launch public-private partnerships focused on circular textile innovation and infrastructure.
- Improve access to capital investment for circular businesses.
- Advocate for favourable tax, trade, and policy incentives to give circular service providers a competitive advantage over linear models and competing EU textile regions.

2. Consumption

Italy, particularly in northern provinces like Milan, has a purchasing power well above the European average, with Milan's per capita purchasing power reaching € 25,077, almost 41% higher than the national average and around 70% higher than the European average.[84] This financial capacity presents an opportunity for consumers to invest in more sustainable and circular products. However, several barriers to engaging with circular options remain. Cultural stigma around second-hand goods, along with challenges such as cost, accessibility, and trust in second-hand services, hinder broader adoption.

Recommendations:

- Address cultural stigma and barriers to second-hand services by promoting the value, quality, and environmental benefits of circular products.
- Expand repair services to ensure greater availability and affordability of circular options.
- Engage influencers, local events, and public campaigns to shift consumer behaviour, enhance the appeal of circular services, and improve the perception of second-hand goods.

3. Waste collection and infrastructure

Overall, accessibility to circular textile services in Prato is strong. An estimated 96% of the population can reach at least one recycling, reuse, or repair point of interest (POI) within a 15-minute walk, and 100% of residents can access all three services within a 10-minute drive. The highest concentration of POIs is found in central neighborhoods, which have the highest population density and lowest average household income. This suggests that the distribution of circular textile services in the city is primarily driven by population density rather than income levels. However, challenges remain in the traceability of textile waste and ensuring that materials are properly recycled rather than landfilled or downcycled. A first estimate suggests that the climate impact of post-consumer textile flows in Prato is 650 thousand tonnes of CO2e per year, underscoring the significant potential for impact reductions through the implementation of R-strategies.

Recommendations:

- Experiment with new collection points and methods; increase geographic coverage

[84] https://fashionunited.com/statistics/global-fashion-industry-statistics/italy

of textile collection bins.
- Invest in piloting and implementing innovative data collection approaches to track post-consumer and post-industrial textile waste flows.
- Support through multiple approaches the existing initiatives focused on the mechanical recycling of textiles, such as Re-Waste, to reduce the need for additional dyeing and other energy-intensive processes[85] and launch complimentary ones.
- Develop circular hubs to increase the visibility and accountability of textile recycling, waste flows traceabiloty solutions, mechanical and chemical recycling, as well as to change the perceptions of reuse, and repair offerings.

4. Employment and labour dynamics

Data gaps remain a significant challenge, restricting the ability to accurately measure circular employment in the textile sector in Prato. The manufacturing of textiles is still the primary employment sector in the city, with 40,032 jobs in this area. Distribution and retail also account for many jobs, but only a small proportion are focused on second-hand retail. Although still modest in numbers, there are estimates available for textile rental, which could present a growing job opportunity in the area. Similarly, jobs in repair services (estimated at 478 jobs) are also notable but still a small segment. The most contested figure remains the number of people involved in collection, sorting, and recycling activities, which is estimated at 600 jobs. However, this figure comes from a local consortium and has not been verified by public authorities.

Recommendations:

- Conduct comprehensive research to assess the extent to which current jobs in the textile sector are contributing to circular practices and design.
- Develop initiatives to foster the growth of circular retail and consumption practices. Focus on expanding activities that promote second-hand retail and other circular retail models to create more job opportunities in this area.
- Establish a baseline for textile recycling jobs by conducting a detailed analysis of the number of individuals currently working in sorting and recycling activities. This should include tracking jobs in collection, sorting, recycling, and related sectors.
- Expand the analysis of support roles within the recycling sector. Given the importance of textile recycling, identify key support positions such as logistics coordinators, quality control inspectors, data analysts, customer service teams, and administrative staff. Understanding the demand for these roles will help identify opportunities for job creation and workforce development.

5.2 Areas for immediate action: Key considerations for pilot design

To succeed in implementing circular textile solutions in Prato, addressing trust, transparency, and community engagement is essential. Effective community involvement will drive participation and overcome barriers to circular services. Additionally, ensuring that services are affordable and competitive through partnerships and economic incentives will

[85] https://www.mics.tech/en/projects/2-08-re-waste-circular-ecosystems-in-textile-chain/

be key to widespread adoption. To ensure these efforts are successful, several strategies should be considered:

- **Implement mobile collection points**: Set up accessible and convenient locations for textile collection, making it easier for residents to participate.
- **Launch repair workshops**: Create community spaces where residents can repair textiles, promoting skill-building and sustainability. In order to design them, a design-thinking led process[86] can be applied including outreach to service users and service providers, including surveys and polls on diverse platforms that enable deepening the understanding of specific and localised habits, words, values and practices that make repair in Prato unique and essential part of the ecosystem.
- **Run awareness campaigns**: Educate the general public, industry stakeholders and policymakers on the environmental and economic benefits of circular textiles, driving behaviour change and increasing engagement.
- **Build partnerships**: Collaborate with local businesses, authorities, and organisations to reduce costs, enhance service offerings, and scale circular services.
- **Offer economic incentives**: Introduce financial incentives to lower the cost of circular textile services, ensuring they are accessible to all residents.
- Learn from existing best practice in piloting community led repair projects, that build on human-centered design[87].

These considerations will guide the effective design and rollout of circular textile pilots, ensuring that they meet the needs of Prato's diverse communities and drive progress towards a more sustainable, circular textile economy.

[86] To access The Circular Toolbox that guides users through a tried and tested circular innovation process and provides the resources you'll need along the way towards the launch of a circular business model that is financially competitive, impact-driven and delights and engages the user. Access here: link

[87] Innovate UK (2025) Next Door Repairs in Hackney. Access here

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