FAU

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ASTER

WP1 | Mapping Economic Flows & Gaps in the Alps

MAPPING THE STATE OF ALPINE SOLUTIONS FOR CIRCULAR PRODUCTS

PART 2

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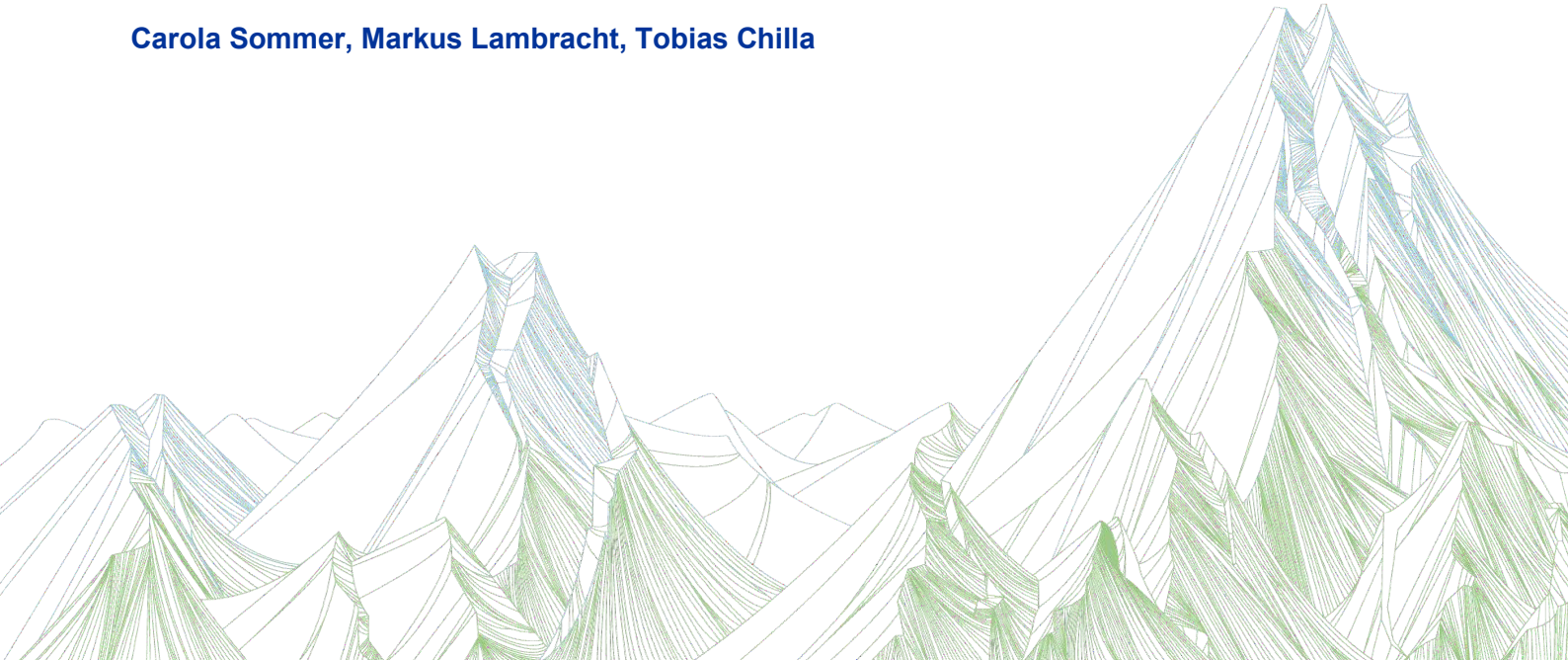

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It provides insights and results from work package 1 (WP1) and structures the understanding in the testing and implementation phases in WP2 and WP3 of the project.

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INTRODUCTION

Circularity in the economic sense

Textiles and plastics play a crucial role in the Alpine Region's economy. Several regions, particularly including Northern Italy, the Auvergne-Rhône-Alps region and Germany, have a long tradition in textile production (Modica 2022, Šrimpf Vendramin et al. 2024, Lambracht and Chilla 2024). Key products of the mountain economy include sport and outdoor clothing, equipment, and infrastructure like ski-lifts. However, while manufacturing such products offers some economic benefits, it also generates significant waste volumes, both during production and at the end of the product's lifecycle. Consequently, the global relevance of plastics has increased. Specifically, between 2000 and 2019, worldwide plastic waste generation more than doubled, reaching 353 million tons (Lebreton and Andrady 2019). Additionally, the rise of fast fashion has boosted global clothing production, further enhancing related commodity flows (Niinimäki et al. 2020).

Globally, textile fiber production has increased by 300% between 1975 (34 million tons) and 2025 (135 million tons), and is expected to further increase by 20% until 2030 (160 million tons). Figure 1 by Textile Exchange (2025) shows that the synthetic fiber production is growing in a particularly strong way, with Polyester (PES) as its main raw material.

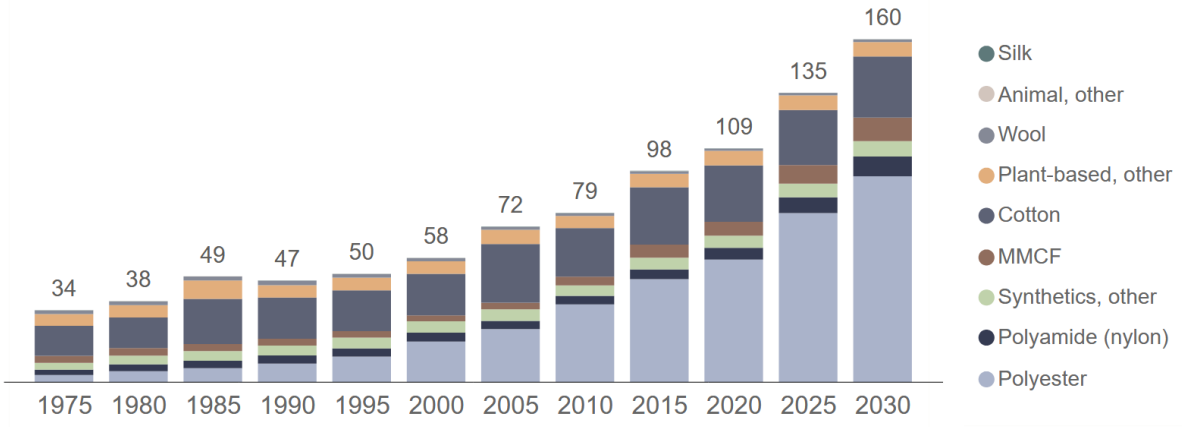

Figure 1: Global fibre production in million tonnes (Source: Textile Exchange 2025)

These increased product volumes have led to greater industrial and political pressure to find economic solutions for the waste challenges. In 2020, the European Union (EU) declared circular economies (CE) a political goal (Bourdin and Torre 2024). Normatively speaking, circularity aims to increase the share of recyclable and recycled textiles, in order to enhance a more sustainable use of virgin materials. Consequently, the creation of sustainable Alpine value chains aims to generate value through circular practices. This approach is embedded in the 5R/10R strategies, which combine practices before and after product creation, such as refuse, reduce, reuse, repurpose, and recycle (Lambracht et al. 2025).

However, in economic terms, the related sectors suffer from limited regional economic viability due to gaps in infrastructure and capacities (Sommer et al. 2026). This is reflected in a lack of viable business models. This strongly affects the underlying material and waste streams, and the potentials to increase value creation. Understanding the territorial specificities of different areas is crucial to envisioning a successful CE transition. Tapia et al. (2021) assert that spatial

dimensions play a critical role in shaping the operationalization of CE at various scales, particularly at regional and local levels.

Through the ASTER project, we aim to address the complexities associated with textile and plastic waste in the Alpine Region, leveraging stakeholder collaboration to innovate solutions and improve resource management in order to create a more sustainable framework for future generations. By focusing on these interconnected issues, the project envisions a comprehensive strategy that not only mitigates waste but also promotes a circular economy that benefits both the environment and the local communities dependent on these vital industries. This report aims to provide an overview of current economic flows and to identify gaps and potentials for textile flows in the European Alps.

This report aims to identify and analyze economic flows and gaps in textile value chains in the European Alps. In addition, the first work package includes five further reports that provide complementary information and deeper insights into the ASTER project. An input paper on R-strategies offers definitions and guidance on understanding and applying these strategies to project activities. Other deliverables focus on providing an overview of the current status and developments within the topics of circular economy, textile production, and R-facilitators, mapping relevant regulations and economic policies for waste prevention and management and analyze institutional dynamics including key contextual factors in the Alpine region. Additionally, one report including two Deliverables analyzes the R-potential, waste generation, and waste management of outdoor products in the Alpine region. These reports provide an important empirical basis for assessing circular economy opportunities within the project.

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Data and Methods

To examine the economic status quo of circular textile and plastic streams in the Alpine region, we apply two complementary mapping approaches.

First, a Sankey diagram visualizes commodity flows, and other flows (Mischke and Xiong 2015). Our approach adopts this kind of diagram to visualize the overall product flows of textiles along circular value chains, including textile production, consumption and several stages of the end-of-life cycle. We do so based on Eurostat data for selected NACE categories (Nomenclature statistique des activités économiques dans la Communauté européenne, see D1.1.1; Pernici et al. 2024).

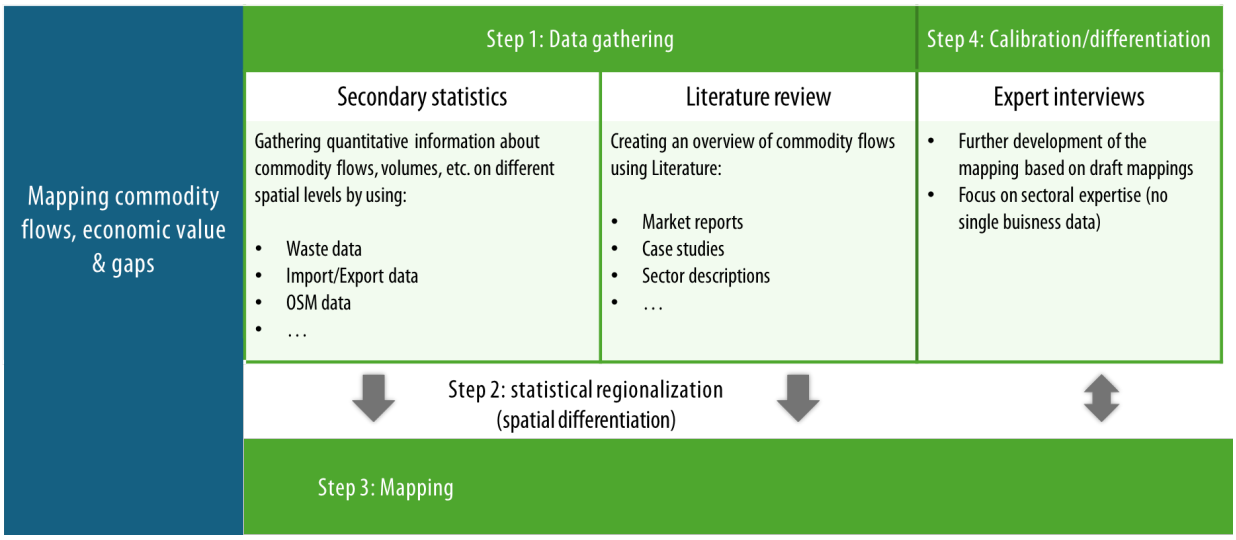

Figure 2: Overview of the Mapping Approach

Second, a value creation mapping contextualizes differentiates these textile flows spatially (Bertram et al. 2021, Wilhelm and Chilla 2023). Based on product volumes and flows, the approach traces textile flows within the Alpine Space perimeter (ASP, see also Sommer et al., 2026). Based on the spatial relationships and interdependencies (regional to global), the approach helps to identify (economic) potential for regional value creation. The creation of both mappings relies on an iterative approach, that combines secondary data from statistical data bases, and primary data from expert interviews (see Figure 2).

TEXTILE AND PLASTIC WASTE STREAMS FROM A GLOBAL PERSPECTIVE

The textile and clothing sectors have largely been described as globally fragmented. Accordingly, they involve a large variety of producers and traders, as well as billions of consumers (EEA 2019). Globally, the textile production has increased by more than 300% since the 1970s (EEA 2025, Textile Exchange 2025). By 2023, the textile segment made up 3.7% of global trade (by turnovers; OEC 2025). This is due to two trends that reinforce each other: a rising fast-fashion trend drives demand, and a greater use of synthetic fibers makes textile production cheaper and more efficient. Between 2010 and 2022, consumption volumes of textiles per person have increased by 15% in Europe, even though raw material use in Europe dropped by 24% in the same period (EEA 2025). Currently, synthetic fibers constitute approximately 60% to 70% of all textiles globally (EEA 2019).

Due to rising demand, the relevance of textiles imports in the EU has increased sharply. The following figures illustrate this: In 2020, the EU was the main import market with 24% of all textile imports, and 34% of apparel imports (Boschmeier et al. 2023). In 2022, the EU imported around 11 million tons of textile products, with clothing accounting for 45% of this volume, household textiles 21%, footwear 17%, and other textiles – including non-wovens, industrial textiles, and ropes – making up 12% (ETC CE 2025). According to EURATEX (2024), this amounted to EUR 153 billion.

At both the European and global levels, textiles are mainly sourced from China, Bangladesh, and Turkey, among others. As textile demand in Europe has risen, China has been the primary beneficiary, surpassing the European Union as a major textile exporter (32% of global exports). Since 2010, the Chinese textile market experienced continuous growth by approximately 30% (WTO 2021). Before the COVID-19 pandemic, the global market share of the Chinese textile segment was at 39,1% (2019), whereas it amounted to 46,5% in 2020.

ALPINE TEXTILE RECYCLING STREAMS

Mapping Description

Figure 3 illustrates the underlying streams of a (circular) textile economy in the Alpine Space region. It draws on qualitative interview data collected through semi-structured expert interviews. In total, four interviews were conducted with representatives of relevant organizations in the textile and textile recycling sector. Each interview lasted 45-60 minutes and was conducted online via Zoom. All interviews were audio-recorded, transcribed, and subsequently evaluated using qualitative analysis methods. The interviews were conducted with the support of graphical elements, which were used as discussion prompts to facilitate reflection on processes, system boundaries, and interrelations within the textile value chain. This visual approach supported a shared understanding with the interview partners and enabled more detailed and structured responses. The interviewees represented associations and businesses from Germany, Switzerland, and France, including one German and one Swiss textile recycling association, a Swiss textile collection company, and a French association representing the outdoor sports sector.

It considers both intra-regional streams and relevant global product flows. The visualization is composed of several elements, including layers, boxes, arrows, and frames. The layers distinguish spatial scales, with a light grey inner boundary delineating the Alpine Space perimeter and a medium grey outer boundary representing the global level. This follows a simplifying, schematic binary between the endogenous, Alpine, and exogenous levels. The boxes are color-coded to differentiate economic stages. Yellow boxes indicate the stages of value creation for both the textile value chain and the waste-handling economic sectors. Meanwhile, green boxes mark stages embedded within R-strategies, such as recycling, energy recovery, and dark grey denotes waste treatment stages that are not part of a circular system. Product flows are illustrated by arrows, whose thickness reflects their relative relevance. Finally, different segments of the system are highlighted using colored frames: yellow frames identify the textile segment of the circular value chain, while orange frames mark waste-related segments.

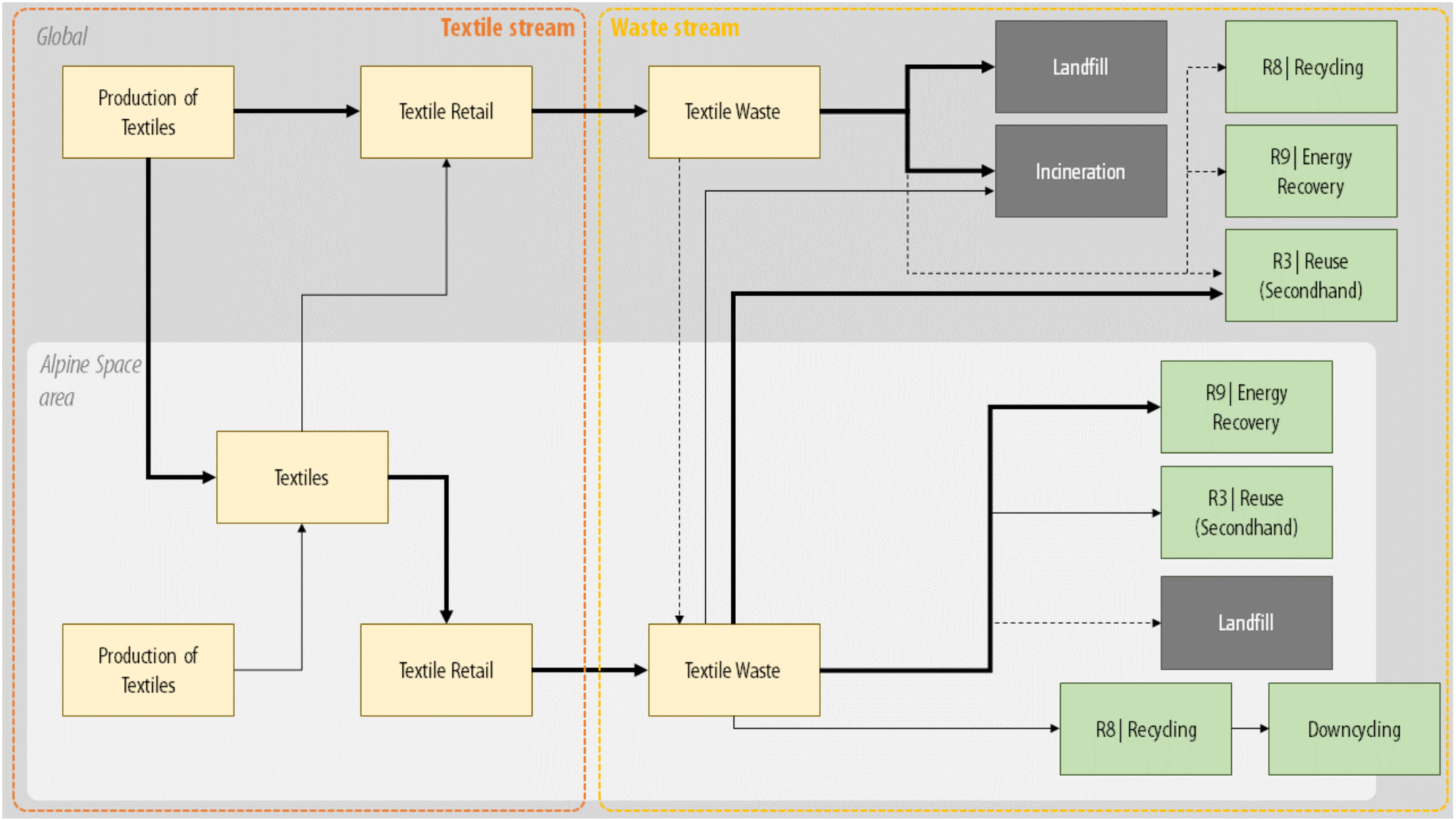

Figure 3: Alpine Textile Recycling Streams

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Findings

The mapping shows that only a few R-strategies are currently economically relevant in the Alpine Textile Recycling Streams. Even fewer circularity approaches can be identified as economically relevant on the global level. Three main findings reflect the current situation.

First, most textiles produced globally end up as textile waste that is treated in a linear manner and ultimately ends up in landfills or incinerators. Second, in some parts of the world, mainly Africa, as well as parts of Asia and South America, a secondhand market exists, but it is primarily supplied by exports from the global North (e.g., the Alpine area). And third, at the Alpine level, only some R-strategies appear to be somewhat effective. Most textile waste is used for energy recovery (R9) or reuse (R3), either in the Alps or globally. A small amount is landfilled or downcycled into cleaning rags (R8). Since only a small part of the industry can be described as circular or dedicated to R-strategies, there is room to identify flows and potentials.

MAPPING MATERIAL FLOWS IN THE ALPS

Mapping Description

The Sankey diagram in Figure 4 visualizes the flows of textiles and textile waste, with regionalized data focusing on the Alpine Perimeter. The Diagram illustrates the quantities of textiles (in tons) for 2020, which move along the value chain and further into end-of-life waste streams. The width of the arrows indicates the quantity of textiles at each stage. There is no regional differentiation among the national or sub-national contexts within this area. The data source for this visualization is Eurostat. The legend describes the color coding: green indicates imports, relevant only before items are used; blue represents exports of textiles and waste streams; yellow shows textiles that remain with the consumer; grey depicts the Alpine streams leading to recycling; and brown symbolizes waste streams.

It is important to note that the data used for this mapping was compiled from various sources, including Eurostat, national statistics, and sector reports. Therefore, the data is inconsistent. Missing data was estimated or filled in using expert knowledge and plausible data bridging. Nevertheless, the data provides an estimated overview of real textile and waste streams.

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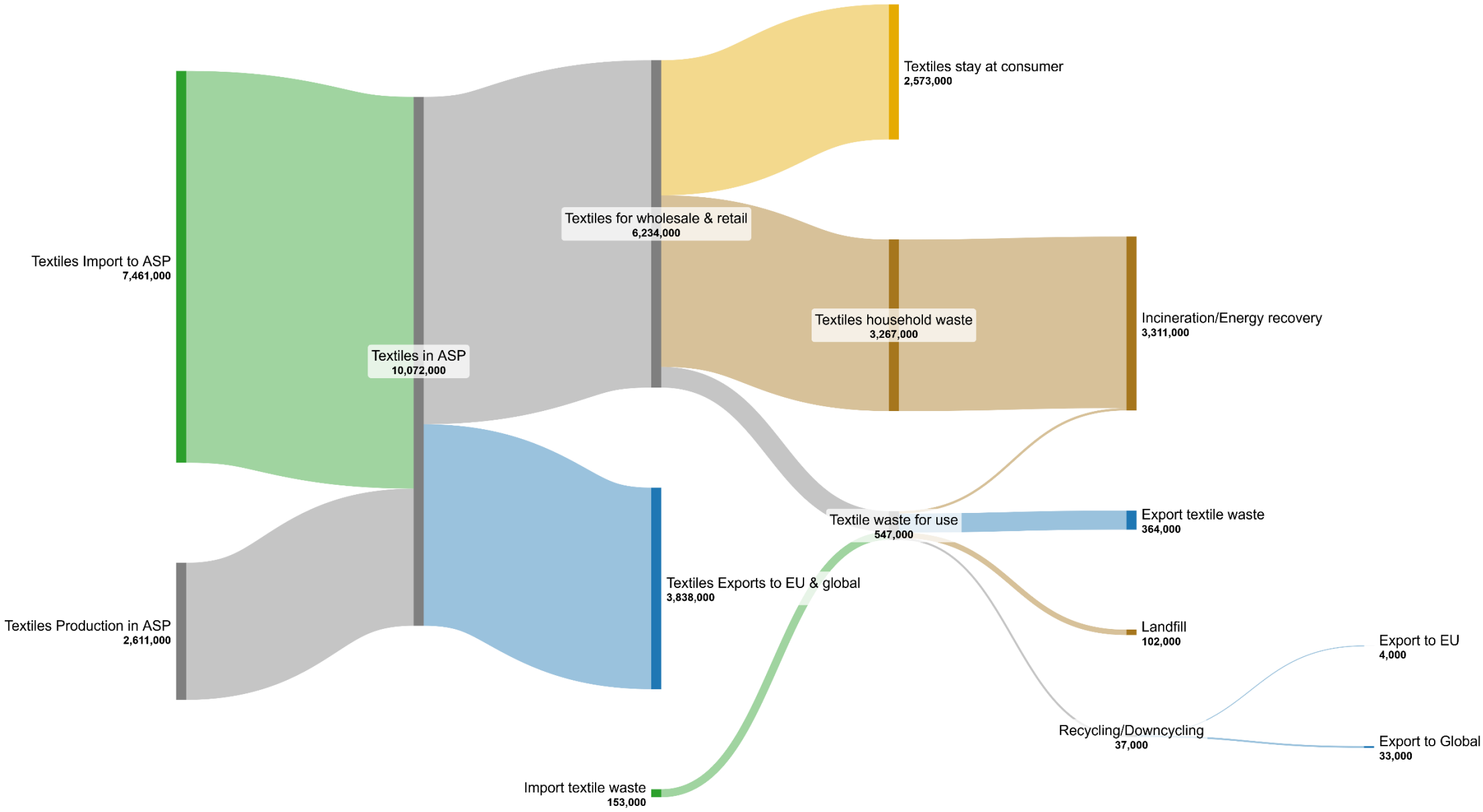

Figure 4: Quantification of Alpine Textile and Waste Material Flows in 2020 (ASP = Alpine Space Programme area, Data sources: Eurostat, EEA, Recovery Worldwide)

Findings

In total, the textile market within the Alpine region amounts to around 10 million tonnes of textiles, which equals an estimation of 7 to 10 billion Euros (Fashion for Good 2026). This volume comprises 7.5 million tons of imports and 2.6 million tons produced within the Alpine region. Approximately one-third is exported to other regions within Europe or beyond (3.8 million tons), whereas the majority of these textiles available on the Alpine market are traded to consumers within the regions (6.2 million tons). Among these 6.2 tons of textiles, 3.3 million tons are disposed of in household waste and 0,3 million tons result in reuse systems (platforms, etc.) whereas it must be assumed that the difference (2.6 million tons) remains with consumers first.

Textiles in household waste are primarily incinerated and used for energy recovery (see also CEF 2024). Even though landfill is legally restricted across most European countries, it is reported that minor volumes are used in this way, too. A minor amount (approx. 0.5 million tons) is collected by different national or regional collecting systems. Of these, the largest proportion of 0.4 million tons are exported as textile waste. Largely, this is because their quality is too low for Reuse. Around 0.1 million tons of textiles are sent to landfills. According to the United Nations (2025), landfills refer to “a scientifically designed and constructed site where waste is disposed of systematically, where all emissions of gases, liquids and solid materials are controlled and not allowed to contaminate the surrounding environment” (see also Bukhari et al., 2018).

By contrast, only 0.04 million tons are recycled, downcycled, or redistributed through private resale platforms, even though this figure is rising. The actual number of recycled textiles cannot be adequately quantified.

Overall, the diagram highlights the high number of textiles which are consumed within the Alpine region, whereas the volume that finds its way into any of the R-Strategies is remarkably low. Rather, textiles tend to end up as household waste and are then incinerated. Reuse, recycling, and high-quality circularity play relatively minor roles in terms of quantity, whereas exports – both of new textiles and waste – constitute an important part of the system.

MAPPING THE ECONOMIC DIMENSION

Mapping Description

The Economic Gap Mapping in Figure 5 is designed to visualize and enhance value creation workflows**.** This mapping extends the Sankey diagram geographically. It represents the data from the flow chart in a spatial context for the Alpine perimeter. The mapping comprises various elements. Grey layers indicated a binary endogenous-exogenous differentiation of by scale, specifically between the Alpine region and the Global level. Beige boxes represent stages of value creation. They include internal differentiation within Alpine countries and regions; yellow boxes denote consumers. Finally, the arrows represent commodity flows, distinguished by type. Green arrows depict textile material streams. Blue arrows show waste streams, such as discarded textiles. The data sources for this diagram are interviews and Eurostat.

The Mapping illustrates the Alpine state of the textile recycling network. In the Alpine region, textiles are primarily produced in Italy, Germany, Austria, and France; however, they only account for about 25% of the Alpine textile retail sector. The majority (~75%) of the textiles traded within the Alps originates from the global market. Among this trade volume, 60% of textiles are sold to consumers in the Alps, while 40% are exported to various global markets.

Both waste streams –global and alpine – end up in potential value creation stages here presented as eight out of the 10 Rs. R5 and R6 are excluded here, as they are not relevant for textile waste treatment (Lambracht et al. 2025). Concerning Alpine textile waste streams, 80% are disposed of in the household waste, nearly all of which is used for energy recovery. Small amounts are still disposed via landfill in Italy and Slovenia. Meanwhile, 20% are disposed of in different systems of textile collection. Italy accounts for the largest share of collected textiles, followed by Germany, Austria, France, and Switzerland. 80% of the separately collected textiles are routed into circular strategies like reuse, recycling, and recovery, while only 2% go directly into lower-quality pathways, mostly used as rags for cleaning. 95% of this R-treated textile waste is exported for second-markets in global south. The remaining 18% are directly exported for recycling or energy recovery. Only about 5% of textiles, such as secondhand items, are returned to consumers within the Alpine area. Globally, 81% of non-reusable textiles are disposed of in landfills or incinerated and therefore remain within a linear system. 19% is directed into formal circular strategies mainly downcycling and energy recovery. The key message conveyed by the graphic is that, despite existing collection and recycling structures in the Alps, most textiles continue to follow a linear path, ultimately ending up in energy recovery, landfilling, or export for reuse. High-quality circular options, like reuse or recycling within the alpine area or the avoidance of waste, currently play a minor role within this system.

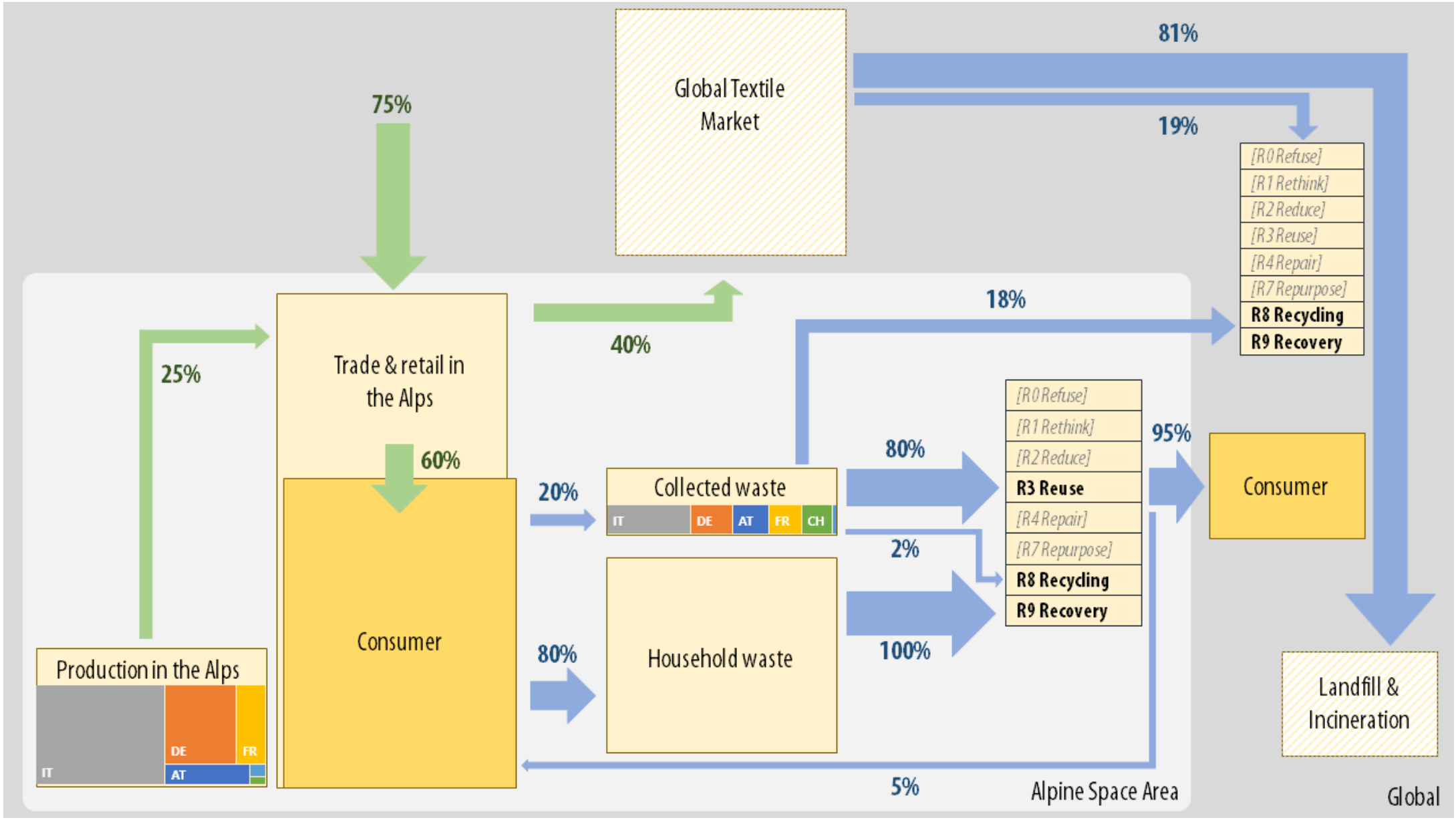

Figure 5: Economic flows of Textiles and Waste

Findings

The analysis based on the mapping illustrates that there are several economic gaps. First, at the global level, a substantial proportion of textile waste is still managed through landfilling or incineration. This reflects persistent global constraints within prevailing waste management systems, including a lack of scalable and economically viable options for textile waste valorization. The continued reliance on end-of-life disposal rather than circular recovery highlights the underlying global market structures. Second, and reinforcing the first aspect, a high share of textiles, which could potentially be (but aren't yet) reused within Europe or even the Alpine region, are in fact exported. Rather than handling waste streams generated within the Alpine region, their processing is transferred to other regions through export. This highlights how limited capacities for recycling/ downcycling or energy recovery hamper a broader economic valorization of regionally generated waste streams.

Second, only a limited subset of R-strategies can be directly linked to specific economic sectors, specifically Reuse (R3), Recycling (R8), Recover (R9, dark blue). This indicates that these strategies are those most readily observable within established production and consumption structures. Their linkage to economic sectors implies that related activities are, to some extent, formalized and captured within existing production statistics, thereby allowing for economic accounting and assessment. By contrast, the overview of R-strategies shows that the majority of strategies (light blue) cannot be clearly associated with any defined economic sector. This lack of sectoral attribution suggests that such strategies are either implemented informally, occur at a marginal scale, or are not systematically integrated into current production systems. As a result, their economic significance remains difficult to quantify, and their applicability within prevailing economic frameworks appears limited. This distribution highlights a structural gap between conceptual R-strategies and their measurable integration into contemporary economic activity. It also illustrates that a large share of responsibility for the completion of R-strategies is associated with consumers.

FINDINGS AND DEVELOPMENT POTENTIALS

Challenges

The Mappings illustrate that the Alpine textile sector faces several challenges, which hamper circular practices. This is illustrated by the fact that only small shares of textile (waste) streams can be translated into economic activities in the scope of the R-Strategies. This contrasts with a high volume of textiles, which are traded both in export and domestic consumer markets. However, at present, only three 'Rs' of the 10R-framework can be considered economically viable: an export-dominated Reuse-sector (R3), a Recycling-sector (R8) that largely relies on downcycling activities but with low product volumes, and, finally, incineration is a relevant cornerstone of the Recover-sector (R9). These current challenges derive from market-related and societal causes.

Among the market-related challenges, several aspects should be pointed out here. First, only a limited amount of textile production continues in Europe. As a result, locally produced recycled materials tend to be more expensive than new materials and, therefore, often lack domestic buyers. This situation creates a disconnect between the availability of materials and the demand for them. Consequently, the industry still relies heavily on virgin materials in textile production. This is because of the price but also quality limitations (e.g., length of fibers). Therefore, final products made of recycled materials tend to be more expensive than those made from virgin materials. Without a market to support these recycled and reintroduced materials, implementing R strategies in an economically sustainable ways, therefore, remains a significant challenge. Moreover, the sector suffers from limited and decreasing skilled labor resources. This further constrains the already sparse volume capacities, raises costs in a sector with rather low margins, and thereby reduces the textile volumes that can be fed back into a circular economy. Finally, a significant issue lies in the collection, as textiles must be uncontaminated to be processed economically. This kind of regulations limit the potential spectrum of textiles to be valorized within stages that fall into the 10R-framework.

Finally, in terms of societal challenges, the high discrepancy between textiles discarded via household waste and those disposed of via collecting systems highlights another challenge. While it must be recognized that the reuse market is increasingly growing within the EU, societal change is necessary for strategies like Refuse (R0), Rethink (R1), and Reduce (R2) to succeed. However, recent studies emphasize that the growing Reuse-market has come along with increasing amounts of textile consumption (e.g. Mizrachi and Sharon, 2025).

Potentials

However, there are some potentials that might contribute to a strengthening of the circular segment of the textile production and recycling in the coming years. These strongly rely on national activities, comprising market-related and political approaches.

Among the market-related approaches, Switzerland illustrates a promising approach. Here, industry solutions have proven successful alongside political pressures such as the EU's EPR. While Switzerland, as a Schengen but not an EU member, is not legally affected by these regulations, the country's economy often aligns with such matters. Hence, the industry aims at developing an industry solution based on generating the economic basis for successful development. This involves establishing the processes based on sufficient potential and

ensuring material availability to develop tested, practical solutions before initiating political and regulatory measures (https://www.fabric-loop.ch/). Technical solutions are already available; they require testing and implementation within a functioning market. Therefore, the Swiss Association *Fabric Loop* supports SMEs in developing and investing in such machinery, to establish internal textile waste flows, incorporating remanufacturing and repair options. The processed material is entirely exported, as there is no local use in Switzerland. Strategic partners, such as those in Turkey, need to be identified.

With a stronger political component, France is currently developing frameworks in order to establish economic structures that increase the circularity of the textile sector. This approach strongly relates to the European Extended Producer Responsibility (EPR), but is subject to the French approach, the so-called Anti-Waste Law for a Circular Economy (AGEC, 2020). Accordingly, manufacturers, importers or sellers of textiles in the French market are responsible for the prevention of waste and ensuring end-of-life management tools for their products. This is based on the “polluter-pays principle”, which obliges the actors who place a product on the French textile market to take on responsibility for these products until the end of their life cycle (##pro.refashion.fr). Within France, a national, state-funded initiative has been founded in order to support market actors in transforming their processes.

At the societal level, an increasing awareness of specific consumer segments, e.g., Outdoor and Sports, further strengthens the consumption potential in applying R-strategies.

Limitations and Outlook

Overall, it must be stated that the data availability on circular textile economies in the Alpine regions is strongly limited. This partly limits the degree of detailing of the analysis conducted for this report.

These limitations arise from several reasons. First, the scope of existing economic classification systems (e.g., NACE) is limited, as R-strategies cannot be directly translated into specific economic sectors. In particular, R-strategies that rely on individual or consumer-to-consumer activities are not captured by standard economic classifications. This constrains data accessibility and availability due to missing classifications, inappropriate attribution within existing categories, and, more generally, insufficient data collection. At the same time, it reduces the informative value of the analysis, as not all R-strategies can be treated consistently. These challenges were addressed through extensive data research, the combination of multiple data sources, and the application of a regional zoom in approach.

Second, a series of interviews provided lots of detail, the access to a broader spectrum of experts was limited. Rapid changes in the legal and industrial state of the art further reduced the willingness of experts to provide interviews or detailed information, thereby hampering the validation of data-driven hypotheses. To mitigate this limitation, participation in expert conferences, workshops, and similar events was required, alongside a strong reliance on secondary literature and sectoral reports.

Finally, further analyses are necessary, particularly through a more explicit consideration of underlying dynamics in a temporally and spatially sensitive manner (see Part 4).

Take-away messages

1. **Market and economic challenges:**

   The Alpine textile sector faces significant challenges, including limited local textile production, high reliance on virgin materials, and a disconnect between the availability of recycled materials and market demand. To date, only three of the 10Rs are somehow economically viable in the Alpine region. First, reuse in terms second hand – mainly as export to the global south or Asia. Second, recycling in terms of downcycling to e.g., rags for cleaning and third, energy recovery. Reducing dependence on virgin resources and addressing financial constraints are essential for valorizing circular practices for both, larger textile enterprises and SMEs in the region of the European Alps.

2. **Drivers of circularity:**

   Commonly, societal change is seen as a precondition to circular economy strategies like Refuse, Rethink, and Reduce. While the second-hand market is growing, increasing textile consumption contrasts with hypothetic increased consumer awareness and shifts toward more sustainable practices to strengthen the circular economy. It remains open to what extent second-hand is an effect of societal awareness or affordability issues. However, on a more general level, the economic development of sustainable and circular textile production might benefit more from forerunners of circularity and proactive innovation rather than adapting to consumer choices.

3. **Circularity through political and market-driven solutions:**

   Collaborative national initiatives, such as those in Switzerland and France, are promising in enhancing the circularity of the textile sector through supportive frameworks and industry solutions. The combination of implementing effective political strategies, alongside technical innovations and market-driven approaches, can strengthen the circular textile economy in the Alpine region.

Reference to other Deliverables

This work package consists, beside this report, of five other reports that provide additional information and deeper insights into the ASTER project:

- **Input paper on R-strategies | Definitions and Understanding. A guideline through the Activities:** Gives insights into different definitions in terms of R-Strategies and their use in ASTER (Link: https://www.alpine-space.eu/wp-content/uploads/2026/02/R-strategies-and-their-use-in-ASTER_V3.pdf).
- **Deliverable 1.1.1 | Mapping circular & textile actors in the Alps:** coming soon.
- **Deliverable 1.2.1 | Regulations and economic policies for waste prevention and management in the Alps:** coming soon.
- **Deliverable 1.2.2 | Mapping institutional dynamics in the Alps:** coming soon.
- **Deliverable 1.3.1 & 1.3.2 | R-potential, waste generation, and waste management of Outdoor products in the Alpine region:** coming soon.

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