



Delft University of Technology

The Journey of a Discarded T-shirt From the Global North to the Atacama Dumpsite

Morell-Delgado, Gemma; Talens Peiró, Laura; Toboso-Chavero, Susana

DOI

[10.1007/s43615-025-00618-z](https://doi.org/10.1007/s43615-025-00618-z)

Publication date

2025

Document Version

Final published version

Published in

Circular Economy and Sustainability

Citation (APA)

Morell-Delgado, G., Talens Peiró, L., & Toboso-Chavero, S. (2025). The Journey of a Discarded T-shirt: From the Global North to the Atacama Dumpsite. Manuscript in preparation. <https://doi.org/10.1007/s43615-025-00618-z>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.



The Journey of a Discarded T-shirt: From the Global North to the Atacama Dumpsite

Gemma Morell-Delgado¹ · Laura Talens Peiró^{1,2} · Susana Toboso-Chavero^{1,3,4}

Received: 26 December 2024 / Accepted: 12 May 2025
© The Author(s) 2025

Abstract

Textile waste management is an increasingly urgent issue due to textile mass production and consumption, which leads to significant waste generation. Strategies for managing textile waste prioritise reuse and recycling over incineration and landfilling. However, reuse and recycling practices performed in the same territory where textiles are consumed remain limited. Instead, used textiles from high-income countries are often exported to the Global South and low- and middle-income countries, leading to numerous environmental impacts in these regions. This study examines the value chain of imported used textiles in the Tarapacá and Santiago Metropolitan Regions of Chile. The results help propose a new methodological framework for environmentally assessing used textile trade practices in importing countries. The study employs a rapid-ethnography and qualitative mixed-method approach, including interactive shadowing and observation, conducted across eight locations. The findings reveal that used textiles enter the country first via ports and then are distributed within importer companies and second-hand retailers. There are initiatives for reuse, recycling, and downcycling, but the findings show that not all imported used textiles are effectively utilized. A portion of used textiles ends up as waste in dumpsites, exacerbating environmental impacts. The study recommends a qualitative and quantitative mixed-method approach to address data gaps and develop more exhaustive studies in importing countries. Future research should focus on quality standards to improve sorting, exporting criteria, and traceability of used textiles. This will enhance trade flow accounting and mitigate environmental impacts in importing countries, especially those from unsorted and low-quality used textiles.

Keywords Textile waste management · Environmental impacts · Used textile trade · Waste import–export · Textile landfill · Circular economy

Introduction

The way textile waste is managed on a global scale represents a critical issue. Given that textiles are a mass-consumed commodity [1] with inevitable disposal, textile waste is currently being mass-generated. The term *textile waste* refers to “textile material that is considered to no longer be an asset as it provides no value to the holder” [2]. In the European Union (EU) alone, it is estimated that 12.6 million tonnes of textile waste were generated in 2019, of which 87% was post-consumer textile waste [3]. Post-consumer textile waste is generated by the end user of the product, thus regular consumers [2]. This category encompasses waste from apparel (including clothing, accessories, and footwear), home textiles and carpets, and technical textiles [3].

Waste management strategies prioritise waste prevention as the primary approach, followed by promoting reuse and recycling to avoid incineration or landfilling [4]. According to European Environment Agency [5] textile waste can regain the status of a textile product after undergoing a sorting process and classifying it as reusable. Post-consumer textile waste that is reusable is often referred to as *used textiles*. However, there are missing guidelines and harmonisation on whether to refer to textile waste or used textiles, which leads to the two terms being used interchangeably in the literature. In this work, *textile waste* refers to that material that no longer provides value, following the definition provided by the International Organization for Standardization [2]. *Used textiles* refer to post-consumer textiles expected to be reused (i.e., second-hand sold) or recycled, no matter if they have been sorted or not, as an adaptation of European Environment Agency [5] to the context of this study.

Effective reuse and recycling at the point of waste generation remains limited in the case of textiles [5, 6]. High-income countries are the largest textile waste generators and, therefore, the dominant suppliers of used textiles [7]. Yet, the second-hand markets and recycling industries in such countries are unable to accommodate the vast quantities of used textiles generated [6]. Consequently, a significant portion of used textiles end up exported from high-income countries to the Global South and other low- and middle-income countries for reuse or recycling [6–8].

For instance, the United States (USA), China, the United Kingdom, and Germany were the principal exporters of used textiles¹ worldwide, in terms of economic value in 2022. Pakistan, the United Arab Emirates, Chile, and Kenya were the primary importers [9]. Similarly, EU data on textile waste reveal that only 0.97 million tonnes of the total post-consumer textile waste generated in the EU (10.9 million tonnes) in 2019 was recovered through reuse or recycling within the EU. In comparison, 1.83 million tonnes were exported to the Global South and other low- and middle-income countries [3]. The value of the global used textile trade has increased by 32% over the last decade, from \$4.29 billion in 2013 to \$5.66 billion in 2022. This expansion has accelerated, as evidenced by a 10% rise between 2021 and 2022 alone [9].

This trade is intended to facilitate the valorisation of used textiles, driven by the existence of a considerable demand for second-hand goods or a substantial recycling and manufacturing industry in the importing countries [6, 10]. However, the exact volume of used textiles that are ultimately reused or recycled once exported remains uncertain [6, 10, 11]. This is because sometimes traded used textiles are not necessarily suitable for reuse or may not

¹ In this study, all economic trade values referred to as “used textiles” are based on the Harmonised System (HS) code 6309 – Worn clothing and other worn articles, using the HS92 dataset.

even be sorted [12]. Also, because available estimates are rough and narrowed to a limited number of studies, most of which are grey literature. Exemplifying this, Paúl [13] and Brunello et al. [14] reported that between 60 and 68% of imported used textiles in Chile are waste or are not sold. Branson Skinner [15] quantified that up to 40% of used textiles sold in Kantamanto Market in Accra, Ghana, leave the market as textile waste. Another recent report revealed that 60% of used textiles in imported bales in Ghana are unsellable because they have no market value in Kantamanto [12]. Their estimates suggested that between 10 and 40% of these unsellable textiles are eventually discarded as waste, while the remainder continues to be commercialised in the market [12]. This contradicts Odonkor [16] who estimates that only 5% of imported used textiles in bales in Ghana constitute waste.

The uncertainty in the used textile trade is partly due to the lack of traceability [11]. For example, the already mentioned misclassification of textile waste as used textiles or used clothing is a tactic employed to evade the regulations on waste exports [11, 12]. Also, resale, recycling, and disposal operations in importing countries are predominantly conducted by informal stakeholders [11, 17], further complicating traceability.

Another aspect worth mentioning is how studies describe the global trade system of used textiles as a form of *waste colonialism* [11, 18]. The waste colonialism concept emerged in response to concerns raised by African countries regarding the global system of trans-boundary waste disposal, which often involves the dumping of waste materials—frequently hazardous—in the Global South [11]. Textile waste has also become a significant part of this issue. Although the EU does not classify textile waste as “hazardous” [19] it is nonetheless a “demonstrably harmful waste category” [11, p.30]. Its trade involves “increasingly documented social and environmental risks” in importing countries [11, p.30], with the accumulation of discarded textiles increasingly observed in natural habitats [12]. However, alternative perspectives argue for the “demonstrably positive economic, social, and environmental impact of the sector” [20, p.4]. Thus, the trade of used textiles offers economic, social, and environmental benefits and disadvantages.

Regarding economic benefits, it is estimated that the import of one tonne of used textiles (referred to as second-hand clothing in Feyertag [20]) creates an average of 6.5 jobs [20], the majority of which are held by women [11, 21]. Similarly, Odonkor [16] affirmed that “the wider positive economic and social impact of the second-hand clothing trade in Ghana is significant” [16, p.5]. Regarding social benefits, imported used textiles provide access to affordable and good-quality clothing for low-income segments of the population, as well as to brands that might otherwise be not sold in the importing country [11]. From an environmental standpoint, the second-hand sector promotes the circular economy by extending the life cycle of used textiles. Extending the life cycle of used textiles via reuse is particularly relevant because it saves resources consumption (e.g., energy and water) and associated impacts [22–24]. It serves as an effective solution for textiles that would otherwise be discarded [11, 16, 17, 20].

The most important disadvantages of textile trade are mainly related to social and environmental impacts in importing countries. Regarding social impacts, Circle Economy [11] raises persistent problems regarding working conditions. Poor working conditions in the sector are exemplified by wages below minimum rates, as observed in India [11]. Also, women and the informal sector are the most affected by lower salaries and poorer working conditions while particularly vulnerable to health and other social risks [11, 17, 25]. As environmental disadvantages, as aforementioned, some imported used textiles end up

as dumped waste. Some identified dumpsites of textile waste are in the Atacama Desert (Chile), in Accra (Ghana), and in Nairobi (Kenya) [26–30]. Dumpsites generate significant impacts on animal habitats and biodiversity, and textile waste in such spaces pollutes the groundwater and soil [12]. This happens because many textiles contain plastics (i.e., polyester) that do not biodegrade but instead break down into microplastics over time, alongside harmful chemicals added during their production. Contaminated groundwater and soil consequently contaminate the food web, introducing further risks to human health [11, 12].

As a result, the trade of used textiles presents complex problems that remain unresolved. Regarding environmental problems, while research has more comprehensively examined the material flows and environmental impacts of textile waste management and used textile trade practices from high-income countries [6, 31, 32], further analysis is urgently needed to understand the trade-offs and environmental consequences in importing countries. This study contributes to this field.

Published data on the environmental impacts of used textile trade are often imprecise, with approximate figures available, predominantly from grey literature [20, 33–35]. Some of these studies employ a multi-method [17] or a mixed-method approach [16] for their assessments or refer to ethnographic research [33]. Other studies do not mention these methods as such, although combining quantitative and qualitative data [20] or conducting field research using interviews [11, 25, 35] and surveys [35, 36]. Most studies focus on African countries (especially Ghana) [12, 17, 20, 36, 37], with limited references concerning Asian [8] or Latin American and the Caribbean (LAC) countries [14, 38]. However, the three regions are grappling with the environmental problems of used textile imports, which renders them all worthy of study. In 2022, used textile imports to Asia totalled \$1.7 billion, nearly matching Africa's \$1.75 billion [9]. Meanwhile, used textile imports to LAC totaled \$868 million² [9]. Notably, the largest and worldwide known dumpsites of textile waste are located in both LAC and Africa [26–29].

To address the environmental problems associated with the used textile trade in importing countries, establishing traceability is essential. Nevertheless, achieving this requires a deeper understanding of the stakeholders, the used textiles value chain, and the management systems operating within these regions. Accordingly, the primary objective of this study is to examine the value chain of used textiles in an importing region from LAC, employing a case study approach. The secondary objective is to develop a methodological framework to environmentally assess used textile trade practices in importing countries. Thus, based on the findings from the case study, the enhanced methodological framework is proposed with the goal of formulating effective mitigation strategies. The novelty of this study lies in the examination of an importing region within the LAC from a scientific perspective, the proposal of a methodology for further scientific research that can be applied globally, and the integration of participatory and social-oriented approaches within a framework designed to assess environmental issues. While this study and the proposed methodological framework focus on the environmental dimension of sustainability, the interconnection between environmental and social issues is also acknowledged [39].

²This value includes used textile imports in the following countries: Argentina, Bolivia Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

Materials and Methods

Case Study

A case study approach was adopted as the research strategy for this study to analyse an importing region. Chile was selected as the country under examination. Chile has seen a significant increase in its used textile imports, rising from the 21st largest importer in 2013 to the 9th in 2021, and ultimately becoming the third-largest global importer of used textiles by economic value in 2022. The country's global market share for used textile imports was 4% in 2022. In that year, imports of used textiles to Chile totalled \$225 million. In 2022, the primary sources of Chile's imports were the US (41.3%), China (23.9%), and South Korea (13.1%) [9]. These data highlight the importance of Chile as the focal point of this study.

Moreover, Chile was not only the largest importer of used textiles in LAC in 2022 but also the leading exporter of the region (\$42.8 million) [9]. This indicates that Chile serves as the gateway for used textiles to the broader LAC market. Most Chilean exports of used textiles in 2022 were directed to Paraguay (74.8%), Peru (10.7%), Venezuela (4.6%), and Uruguay (4.5%) [9]. This trading dynamic is facilitated by the favourable import conditions in Chile, which include an extensive network of free trade agreements that eliminate tariffs, impose no quantity restrictions, and only require fumigation to sanitise imported shipments. These conditions stand in contrast to the bans on used textile trade in neighbouring countries such as Argentina, Bolivia, Brazil, Colombia, and Peru, as well as in other LAC countries such as Ecuador, Mexico, Paraguay, and the Dominican Republic [14].

This assessment was conducted in northern Chile, with a particular focus on the Tarapacá Region and the Santiago Metropolitan Region. The Tarapacá Region is of special relevance to this study due to the presence of the Port of Iquique, the Iquique Free Trade Zone (ZOFRI), and the Atacama dumpsite. The Santiago Metropolitan Region is home to the capital of Chile, Santiago. It is estimated that approximately 40% of imported used textiles by mass entering Chile pass through the port of Iquique. This is the main port of entry. Port of San Antonio, situated in the Valparaíso Region adjacent to the Santiago Metropolitan Region, is the next most significant port of entry [14]. The ZOFRI is also situated in Iquique. It plays a pivotal role in facilitating substantial import volumes. The ZOFRI is the primary free trade zone in Chile. It operates under the Free Trade Zone Law [40]. It is a geographical area where business development is promoted through the exemption of income tax, value-added tax, and import levies. The ZOFRI hosts over 2000 businesses and 1032 sites across an area of 871,466 m². Approximately 50 companies are involved in the import and distribution of used textiles [14]. Additionally, the Tarapacá Region is home to what is widely recognized as a large dumpsite for textile waste in the Atacama Desert [41]. This is not merely an isolated dumpsite comprising solely textile waste; rather, it is a combination of micro-dumps, the majority of which are concentrated near the town of Alto Hospicio, close to Iquique. The estimated number of micro-dumps within the area ranges from 100 to 200 [14, 42], three of which are large and consist exclusively of textile waste [14]. Variances in these estimates may be attributed to the fact that “new landfills emerge every day” [42]. In 2022, it was estimated that over 300 hectares of the Atacama Desert were covered by textile waste.

Rapid-ethnography and Qualitative Mixed-method Approach

The method used in this study is based on a variant of traditional ethnography. Ethnography is a social science method for collecting data. Typical ethnographic research employs three kinds of data collection: interviews, observation, and documents to draw conclusions about how societies and individuals function [43]. According to Blomberg & Burrell [44] ethnographic research (1) takes place in natural settings, (2) is holistic (i.e., understanding is framed in systems larger than the immediate context), (3) is descriptive, and (4) strives to consider the participant's own perspective. However, achieving a deep understanding and preserving the interpretive nature of ethnographic research are typically correlated to long-term fieldwork [45]. Ethnography is considered time-intensive; thus, rapid ethnography has emerged as an alternative approach to overcome the time limitation of the conventional method [46].

Rapid ethnography is considerably faster, as it can be typically conducted over several weeks or months, and more targeted in data collection than ethnographic research [46]. This shorter timeframe limits the depth of exploration into certain aspects of an issue or community. Nevertheless, rapid ethnography still offers policymakers and decision-makers the benefits of ethnographic research in a timely and efficient manner [47]. It is a team-based, multi-method approach that is relatively low-cost [48]. According to Sangaramoorthy & Kroeger [48] rapid ethnography is particularly valuable: (1) when further information on a problem is required, (2) when a problem may be emerging or evolving, (3) when reaching hidden or vulnerable populations is necessary, (4) when a programme or policy requires planning or adjustment, or (5) when community involvement is essential.

Considering that the objective of this study aligns with the reasons why rapid ethnography is deemed valuable according to Sangaramoorthy & Kroeger [48], and due to time constraints, rapid ethnography was considered a suitable method for this study. This investigation uses an adaptation of the rapid ethnography approach proposed by [49] and is based on a preparation phase followed by a field study phase prior to data analysis. In the present work, the two phases are referred to as desk research and fieldwork, and they are followed sequentially. Desk research serves as a precursor to fieldwork, providing the informed foundation for designing the subsequent fieldwork. Moreover, a qualitative mixed-method approach was applied within the framework of rapid ethnography. Both, multi-method and mixed-method approaches had previously been used in similar studies [16, 17], however, mixed-method was selected for this study as “it enables the completion of a single research project more expeditiously and efficiently than conducting a multiple methods” research [50, p.14]. Qualitative mixed-method research comprises a qualitative core component with qualitative supplementary components [50]. The phases applied in this research are outlined as follows:

- Desk research. It was initially conducted to prepare for the forthcoming fieldwork. This involved reviewing information on the used textile trade and the textile waste management situation in Chile. This was mainly done by reviewing media outlets (e.g., digital international and local journals, local blogs, magazines, etc.) through Google searches that included various combinations of the terms ‘textile’, ‘clothing’, ‘waste’, ‘management’, ‘second-hand’, ‘recycling’, ‘Atacama’, ‘dumpsite’, and ‘landfill’, in both English and Spanish. Additionally, this task facilitated the identification of key stakeholders.

They were contacted both before and during the fieldwork in Chile to gain an understanding of the broader context.

- **Fieldwork.** Primary qualitative data was collected in Chile via interactive shadowing, as described by Halme et al. [49]. This method involves close interaction with the local population, where researchers actively socialise and share parts of daily life, rather than simply observing or asking questions. This approach fosters deeper connections, moving beyond typical “hanging out” or informal interviews to promote a greater sense of reciprocity [49]. In this study, interactive shadowing was the core component of the mixed-method approach, combined with social research methods such as informal interviews, observation, and photography [51]. It was anticipated that the combination of these qualitative methods would yield an initial overview of the context through the direct acquisition of on-site information. Data were collected through note-taking and photography. Eight locations were visited and examined between April and May 2023. These included ports, importers’ facilities, second-hand markets, a company reusing and recycling, and the Atacama dumpsite. All visits took place in the Tarapacá Region and the Santiago Metropolitan Region. Additionally, a local second-hand market in La Paz, Bolivia, was visited to examine the re-export of used textiles imported into Chile and distributed to other LAC countries. Given that both the community and the researcher had Spanish as their first language, there was no need for a language facilitator. Verbal informed consent was obtained from all participants prior to any conversations or interviews. Participants were verbally informed that all conversations and responses would be treated anonymously, ensuring that no individual could be identified, with only the sector to which they belonged, and their location being recorded. These measures were implemented to ensure the confidentiality and privacy of all participants. Data were analysed considering three key aspects outlined for investigation during fieldwork. The first aspect was the type of stakeholder or site. Sect. “[The Value Chain of used Textile Imports in Chile](#)” is divided into sub-sections that address each type of stakeholder or site identified. The second aspect involved analysing the main interactions between the identified stakeholders or sites. This helped to understand the direction and movement of imported used textiles within the used textiles value chain. Indeed, the sub-sections of Sect. “[The Value Chain of used Textile Imports in Chile](#)” are organised according to this movement. The third aspect focused on examining the interaction of the stakeholders or sites with imported used textiles. This examination specifically concentrated on three stages: the reception of used textiles, the sale of used textiles, and the disposal of used textiles (i.e., when used textiles are not sold). Additionally, questions regarding the Atacama dumpsite were consistently addressed with all participants. The insights from this analysis constitute the results and inform the discussion presented in the sub-sections of Sect. “[The Value Chain of used Textile Imports in Chile](#)”. It should be noted that interactions and the particular subjects discussed slightly differed depending on the interpellated stakeholders.

The data collected enabled the identification and mapping of key stakeholders and sites in the Chilean used textiles value chain. Additionally, testing the proposed methodology provided insights for developing a future methodology to assess the environmental impacts of used textile trade in other importing countries, as well as for devising effective mitigation strategies.

While quantitative data might be available under other types of research, it was only through on-site qualitative data acquisition that a deeper understanding of the problem could be gained. Used textile trade is not solely a matter of volume quantities and flows. The methodology employed in this study offered a more comprehensive understanding of how the system operates and how it relates to environmental concerns in the used textile trade.

Results and Discussion

The results of this study are presented and discussed concurrently. These are organised into two main sections (i.e. Sect. "[The Value Chain of used Textile Imports in Chile](#)" and Sect. "[A Methodology for Environmental Analysis of used Textile Trade in Importing Countries](#)"). Sect. "[The Value Chain of used Textile Imports in Chile](#)" addresses the first part of the study's objective: to examine the value chain of used textiles in an importing region from LAC. This section is further divided into sub-sections, each focusing on a key stakeholder or site within the value chain of imported used textiles in Chile. Sect. "[A Methodology for Environmental Analysis of used Textile Trade in Importing Countries](#)" addresses the second part of the objective: to develop a methodological framework for assessing the environmental impacts of used textile trade practices in importing countries. Accordingly, Sect. "[A Methodology for Environmental Analysis of used Textile Trade in Importing Countries](#)" proposes a methodology.

The Value Chain of used Textile Imports in Chile

The Chilean value chain of imported used textiles is principally delineated by the stakeholders and sites illustrated in Fig. 1: ports acting as the entry point for imports, wholesale sales conducted by importing companies, retail sales facilitated by local retailers in second-hand markets, textile waste disposal occurring in dumpsites, and companies engaged in the reuse, recycling, and downcycling of pre-consumer and post-consumer textile waste. The identified key stakeholders are consistent with those previously reported by Brunello et al. [14] in Chile, and Bekkevold Lingås & Mailund Rebsdorf [33] in Kenya. Furthermore, the influence of governmental regulations and the re-export of used textiles from Chile to other countries were identified as additional factors contributing to the value chain. However, these were not subjected to in-depth analysis.

The inferior diagram within Fig. 1 illustrates the movement of used textiles across the identified key stakeholders and sites shaping the value chain of imported used textiles. Used textiles from the Global North are imported into Chile and LAC via maritime transport, arriving at Chilean ports. Subsequently, the importing companies manage the imported goods, acting as intermediaries and wholesaling the used textiles to local retailers, retailers from other countries, or other intermediaries. The retailers then sell the textiles in second-hand markets or, in some cases, stores. A portion of the imported used textiles ends up in the Atacama dumpsite. Such waste originates from both the importing companies and the second-hand retailers. Another portion of the imported used textiles, which are sold and utilised by the population in the importing country, enters reuse, recycling, or downcycling channels through local companies focused on promoting material circularity.

The following sections present insights for each of the five key stakeholders and sites identified and mapped in Fig. 1. A further section is included, which addresses the relationship between two of the stakeholders (importers and second-hand retailers).

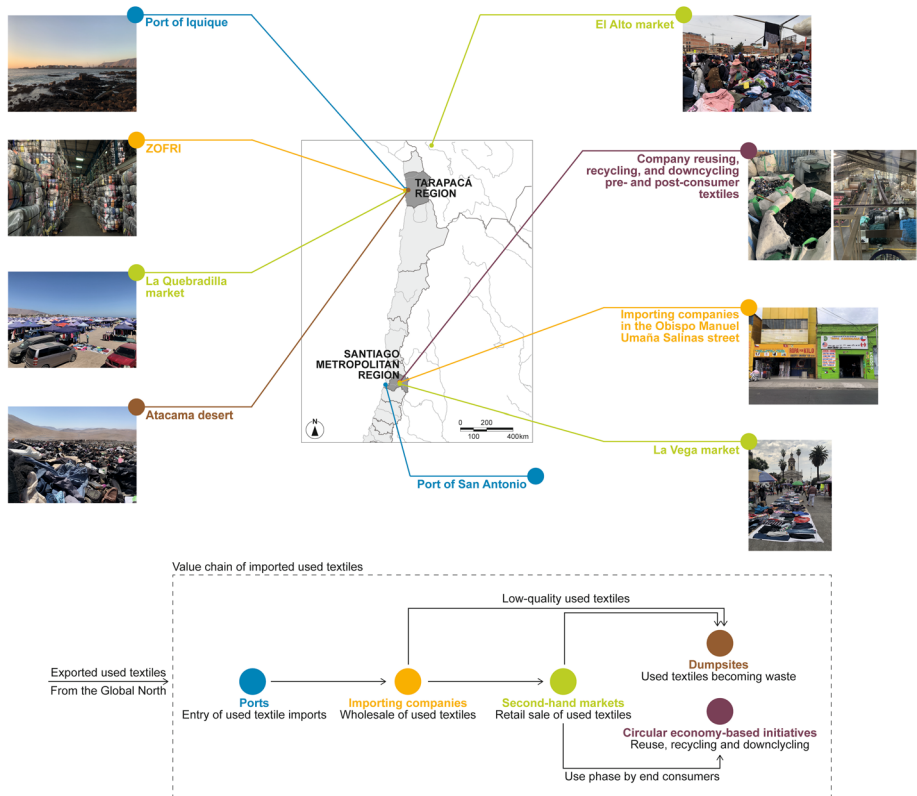


Fig. 1 Key stakeholders and sites in the value chain of imported used textiles in Chile, identified within the Tarapacá Region and Santiago Metropolitan Region

Ports

Ports serve as the principal point of entry for imported used textiles. In the Tarapacá Region, used textiles are imported through the Port of Iquique, located within the region. Used textiles destined for the Santiago Metropolitan Region are imported via the Port of San Antonio, situated in the Valparaíso Region. Imported used textiles arriving at these two ports are also distributed to other regions in Chile and other LAC countries. National statistics also identified Iquique and San Antonio as the main ports receiving used textiles [14, 52].

It is plausible that additional ports close to the Santiago Metropolitan Region also provide used textiles to the region, for example, the Port of Valparaíso. However, it was found that importers “predominantly purchase from San Antonio”. This might be explained because San Antonio is the main port for imported goods in Chile [52, 53] and thus one of the main ports importing used textiles [14]. While the Port of Iquique is another principal entry point of used textiles, “transportation costs from Iquique to Santiago are higher”. The Port of San Antonio is situated 114 km from Santiago, whereas the Port of Iquique is 1761 km away [54, 55]. Because of this, San Antonio is the port providing used textiles to the Santiago Metropolitan Region.

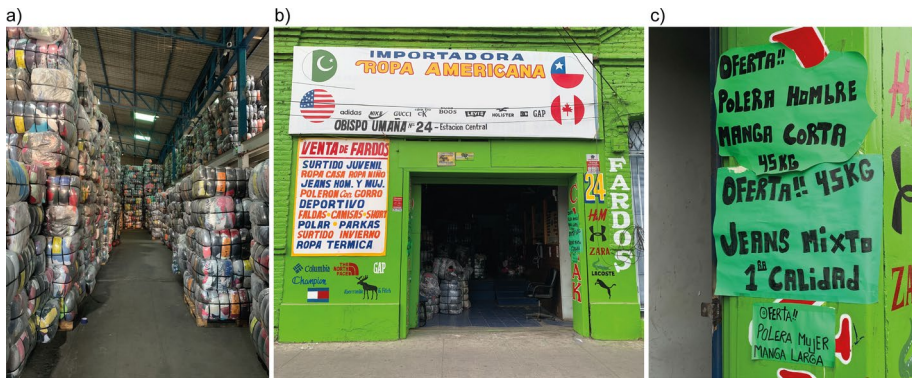


Fig. 2 **a)** Interior of an importing company warehouse filled with bales of imported used textiles (ZOFRI, Iquique); **b)** Exterior of an importing company warehouse (Obispo Manuel Umaña Salinas street, Santiago); **c)** Close-up of offers displayed on the wall of an importing company warehouse (Obispo Manuel Umaña Salinas street, Santiago)

Importing Companies

Imported used textiles are distributed by importing companies on a wholesale basis. Both pre-consumer and post-consumer textiles were observed within the imported textile flows, with post-consumer textiles being more prevalent. Used textiles arrive at importing companies in the form of bales, referred to as “fardos” in Spanish. Figure 2a depicts the interior of a warehouse belonging to an importing company, filled with these “fardos”.

Used textiles reach importing companies in sorted bales – containing textiles that have already been sorted in the country of origin –, or in unsorted bales. This finding is consistent with prior research conducted in a region from the Global North, which documented the export of both sorted and unsorted bales of used textiles [6]. The content of the bales varies in terms of piece type and quality. In some cases, piece types and qualities are mixed within a single bale, while in others, they are separated, depending on whether sorting has occurred in the country of origin. Figure 2b illustrates how an importing company advertised the origin of the bales sold: “ropa americana”, meaning American clothing. They also announced the item type in the bales: “ropa niño” translated to children’s clothes, or “ropa térmica” translated to thermal garments. Figure 2c highlights specific offers detailing item type, quality, and bale weight. For example, “45 kg jeans mixto 1ra calidad” refers to 45 kg of mixed men’s and women’s jeans of first quality.

For the case of sorted bales, importing companies re-sell them directly to other distributors or retailers without opening them. In the case of unsorted bales, importing companies “open them and sort their content by garment type and/or quality”. Importers in the ZOFRI sold 38 kg bales of high-quality used textiles (i.e., first quality) “for between 200,000 to 250,000 Chilean pesos” (CLP) (equivalent to 225€ to 280€³), and lower quality (i.e., third quality) “for CLP 150,000” (approximately 170€). These prices were consistent with those observed among other importers in the Obispo Manuel Umaña Salinas street. The offer shown in Fig. 2c, a 45 kg bale of first-quality jeans, was priced at CLP 200,000 (approx-

³Exchange rate considered is 1 CLP = 0.001124€, according to the exchange rate provided by Exchange-Rates.org [78] for April 26, 2023.



Fig. 3 Used textiles (mainly clothing) sold in various markets: **a)** Street close to La Vega market in Santiago (Chile); **b)** La Quebradilla market in Alto Hospicio, near Iquique and the Atacama dumpsite (Chile); **c)** El Alto market, near La Paz (Bolivia)

mately 225€⁴). Those sorted bales “originated from Turkey”. The mentioned prices at which importers sell the bales remain competitive. Considering data from Brunello et al. [14] each bale from the offer depicted in Fig. 2c may contain 100 pairs of jeans. Retailers only need to sell 40 pairs of jeans (40% of the content) to make a profit [56].

Regarding textile waste generation, some importers shared strategies to minimise textile waste, given the lack of clarity around textile disposal methods in Chile. Sorted bales are not opened by the importers and are expected to contain only good-quality textiles, thereby preventing waste generation on the importers’ side. However, unsorted bales sometimes contain poor-quality or unusable textiles. Importers use these low-quality textiles to complete the filling of bales that they have already prepared for sale after sorting. The rationale behind this practice is to “maximise the use of all purchased textiles, as bales, and thus textiles are bought and sold by weight”. Then, importers have an economic incentive to utilise as much material as possible.

However, despite the applied strategies, the reality persists that not all textile waste can be prevented once used textiles have entered the country. Because of this, importers were asked about the Atacama dumpsite. They expressed ambivalence, with some evincing reticence or discomfort in addressing the issue. One importer suggested that second-hand retailers might be responsible for dumping textiles in the Atacama Desert. The reason provided was that “retailers could not sell their entire stock and lacked sufficient storage”.

Retailers in Second-hand Markets

Retail sales are facilitated by local retailers in second-hand markets. Stores and online platforms are also used according to Brunello et al. [14]. This study focused on second-hand markets. The research identified small-scale markets within urban areas (Fig. 3a) and large-scale markets on the outskirts of towns (Fig. 3b) or in neighbourhoods (Fig. 3c) near major cities.

⁴Exchange rate considered is 1 CLP = 0.001134€, according to the exchange rate provided by Exchange-Rates.org [78] for April 17, 2023.

La Quebradilla was the biggest market visited, located on the periphery of Alto Hospicio close to Iquique (Fig. 3b). This market consists of approximately one thousand vendor sites spread over more than one kilometre, with a width of forty to one hundred metres [57]. Additionally, second-hand markets in neighbouring countries such as Bolivia were found (Fig. 3c) due to the re-export of imported used textiles from Chile. In fact, Chile was the main country of imported used textiles in Bolivia in 2022, in terms of economic value [9].

Regarding textile waste generation, a second-hand retailer shared her strategies for minimising it. When certain garments remained unsold, she first reduced prices. This practice seemed common among other second-hand retailers, as suggested by various posters advertising “remate final” (meaning discounts) at different vendor sites. This strategy also aligns with findings from Odonkor [16] which identified discount sales as the most common strategy used by African traders to manage unsold goods in their inventory. If the items remained unsold despite the price reduction, the Chilean retailer donated them to the gypsy community, children, or the church. This practice is also consistent with Odonkor [16] research, which highlighted donations to charities as another common practice. However, the adoption of this strategy often results in the most vulnerable stakeholders within the value chain absorbing the social and environmental impacts associated with imported used textiles that are not fit for reuse [11].

Only the second-hand retailers from La Quebradilla market were asked about the Atacama dumpsite. This topic even though sensitive was more openly debated, compared to importers. They identified importers of used textiles as the primary users of the dumpsite, as they need to dispose of the low-quality textiles received in unsorted bales that should not be sold to retailers.

Used Textile Trade Between Importing Companies and Retailers

Conversations with importers and second-hand retailers confirmed that not all imported used textiles intended for reuse in Chile are ultimately sold and utilized. Furthermore, it was evident that viable alternatives for textile waste management are lacking. Interviewees offered various reasons justifying why their low-quality unusable or unsellable used textiles were not disposed of in the Atacama dumpsite. These reasons were identified as strategies for textile waste prevention. However, these strategies had been independently developed by individuals or companies, and all shared a common limitation: the strategies merely displaced the problem of managing textile waste from one place to another, rather than addressing the problem at its source.

Figure 4 summarises the movement of imported used textile flows across the examined value chain in Chile via a decision tree. This decision tree revealed that unusable and unsellable used textiles, along with their waste management, represent the main environmental issue resulting from imported used textiles for the importing country. These textiles are typically of low quality. Accordingly, the core problem within the system can be defined and summarized as follows: (1) it exists a continuous accumulation of low-quality used textiles entering the country, primarily through unsorted bales, (2) low-quality used textiles end as waste, sooner or later, within the importer country, and (3) there is lack of textile waste management alternatives in the importing country. Moreover, this situation is worsened by low-quality used textile flows being unknown and untraceable.

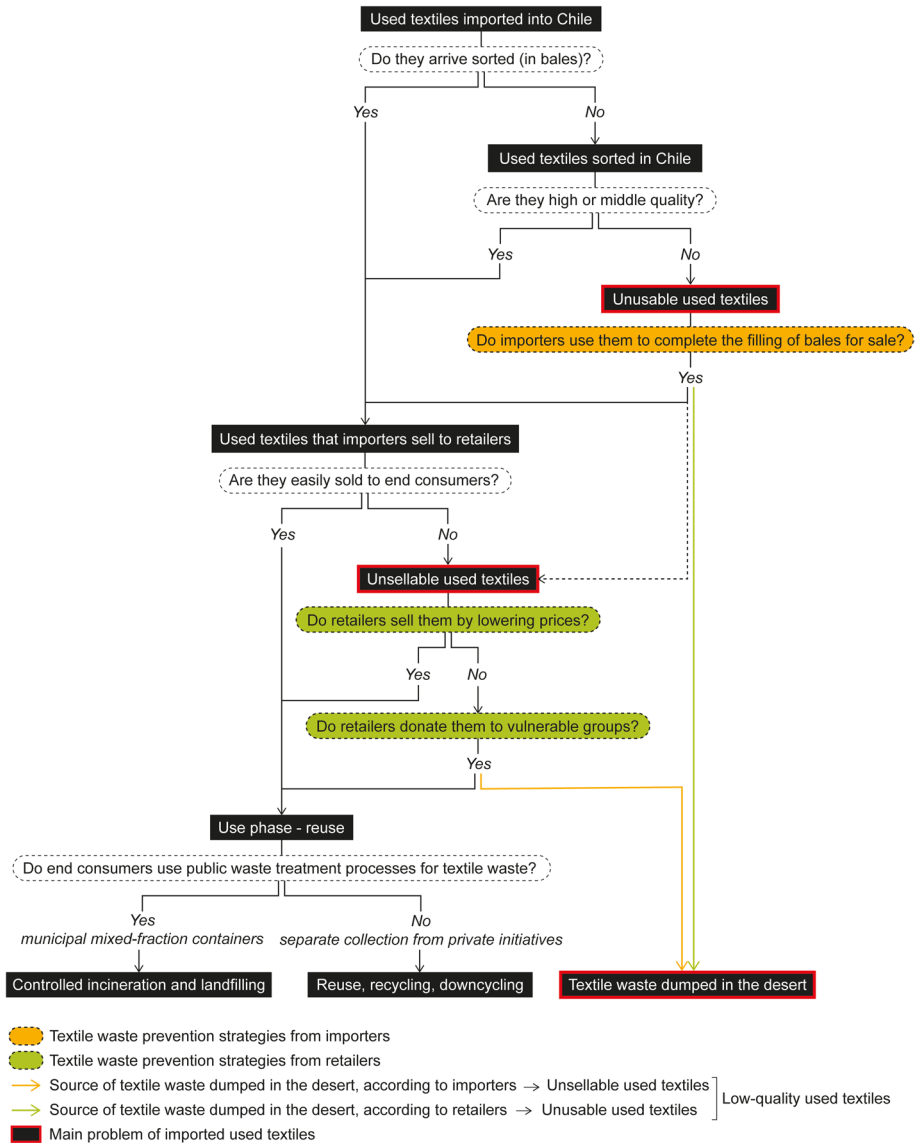


Fig. 4 Decision tree of imported used textiles in Chile: movement of imported used textiles within its value chain

The identified problem originates in the Global North, where textile products are consumed massively and as a result, high quantities of used textiles are generated. Nonetheless, as shown in Fig. 4, the problem persists for importers, retailers, and even more vulnerable groups from the Global South or low- and middle-income countries, who might receive large quantities of used textiles, some of which may be unusable and unsellable. Regardless of the final stakeholder responsible for handling the textiles, the underlying issue remains

that, within the current system, these textiles will inevitably cease to be functional and are likely to be dumped, generating environmental and social impacts on the local population.

Some initiatives have been raised to address the identified problem and prevent environmental and social impacts due to used textile trade in importing countries. However, these initiatives only address the first part of the problem (1), albeit to a limited extent, focusing on all-quality used textiles entering the country, instead of unsorted bales or low-quality used textiles. These initiatives are bans and restrictions on exporting and importing used textiles. However, it has been suggested that “export bans are not the most appropriate way to address used textiles’ adverse socio-environmental impacts” [11, p.43] because, as already mentioned in the Introduction section, used textile trade still provides economic, social, and environmental benefits for the importing country [11, 16, 17, 20]. Moreover, bans may not effectively eliminate undesirable practices, as illegal waste flows already exist [11]. However, examining the specific characteristics that define unsellable textiles in importing countries could play a crucial role in preventing textile waste generation. Such a characterisation was previously conducted in Ghana [58], where the identified issues included the poor quality of garments and their unsuitability for Ghana’s climate.

Another aspect detected when comparing conversations with importers and second-hand retailers was their tendency to shift responsibility onto one another. Both groups also pointed to the responsibility of the government. This aligns with Brunello et al. and Ellen MacArthur Foundation [14, 59], which explain that large volumes of textile waste ending up in the Atacama dumpsite are due to insufficient infrastructure for the controlled incineration and landfilling of textile waste. Conversations with importers and second-hand retailers further emphasised the importance of examining not only each stakeholder individually but also their interrelationships when assessing the system. Such an approach could help gain a more precise understanding of the main textile waste generators and identify the possibilities to reduce the present amounts.

Atacama Dumpsite

The Atacama dumpsite was visited on 27 April 2023. The visited site is located 24 km from the ZOFRI and 12 km from La Quebradilla market [60, 61]. It is accessible by road transportation and a 15-min drive from La Quebradilla. Situated close to Alto Hospicio, the dumpsite is well-known to some local population who occasionally visit the area of the desert “to escape the urban environment”. Thus, the dumpsite is in an easily accessible location, where it seemed that anyone could enter. In fact, the dumpsite is located in public land owned by Chile and whose administration and care, to a greater extent, falls under the responsibility of Alto Hospicio [62].

Discarded textiles (mostly clothing) and other waste materials were visible throughout the area (Fig. 5a). Also, many zones were covered in ashes (Fig. 5b), and some piles of clothing and other textiles were actively burning (Fig. 5c). It appeared that some individuals were residing at the site. They informally managed the textile waste accumulation by selecting some pieces and incinerating waste piles. This finding was unsurprising, given the key role of the informal sector in waste management in the Global South [63] and within the used textile paradigm [17, 38].

Local people suggested that the government was aware of these practices. They believed the government allowed this informal burning practice because incinerating textiles reduced

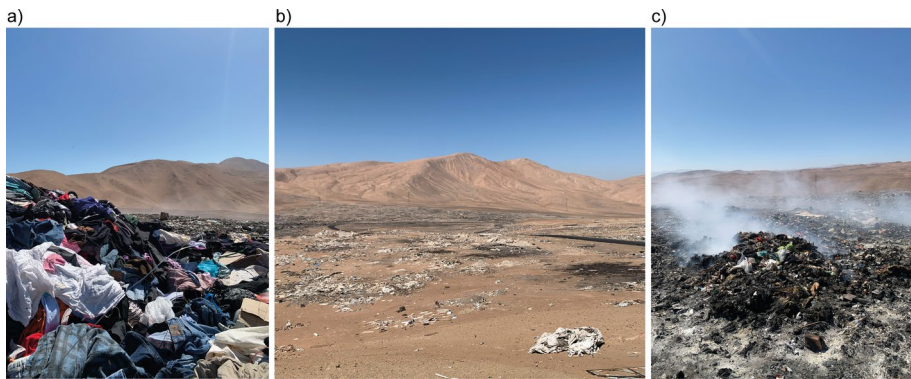


Fig. 5 Textile dumped in the Atacama Desert: **a)** Recently dumped clothing and other textiles; **b)** Blackened areas of the desert sand indicate ashes from previously burned waste; **c)** Clothing and other textiles in the process of being burned

the visible waste to ashes. Consequently, the viral image of large piles of dumped clothing in the Atacama Desert, photographed by Martin Bernetti and first seen in November 2021, would no longer be possible [64, 65]. These opinions aligned with a statement shared in Brunello et al. [14]: “The clothing waste problem has had a lot of media coverage in recent years, showing what is happening in the region. This has made some of those responsible for discarding clothes change their behaviour. They usually go up (to Alto Hospicio) during the night or early morning and often set fire to the clothes immediately after throwing them there” [14, p.12]. It is not coincidental that local people use the term “quemaropa” which translates to “burn clothes”, to refer to the dumpsites.

Dumpsites have already been identified as a source of environmental impacts in the Introduction section. They impact animal habitats and biodiversity, and pollute the groundwater, the soil, and consequently the food web [11, 12]. Additionally, the burning of textile piles was identified as a source of additional environmental impacts and health risks for the local population. The burning of textiles produces black smoke that further pollutes the air [12]. Moreover, air sampling conducted in Ghana confirmed that the surrounding population is exposed to toxic chemicals, many of which exceed European safety standards, including carcinogenic compounds [12].

During the brief visit to the desert, a truck of unknown origin entered the area and disposed of textiles. While it is likely that this was merely coincidental, there is also a possibility that this event was not an isolated occurrence. In fact, this observation was consistent with the statement of the mayor of Alto Hospicio in 2022, who explained that importers of the ZOFRI “hire freight workers or collection trucks and pay them to go dump anywhere” [13]. Additionally, this statement also corroborated the earlier views expressed by second-hand retailers (in the Sect. “[Retailers in second-hand markets](#)”) suggesting that importers were dumping textiles in the desert.

Circular Economy-based Initiatives to Prevent Textile Waste

The significant input of used textiles, which are intended to be reused by the population and ultimately destined to become waste, stands in contrast with the absence of a formal

separate collection system of textile waste at the municipal level. In Chile, municipal textile waste is collected as part of the mixed waste fraction and subsequently disposed of in landfills or formal dumps [38]. While there is an urgent need for government-led solutions to manage textile waste, valuable local initiatives promoting textile waste prevention through circular economy models have emerged. These initiatives come from companies engaged in the separate collection, reuse, recycling, and downcycling of pre- and post-consumer textiles. One company was visited, while another one was contacted, with each representing distinct valorisation processes, diverse sources of textile waste, and one for each of the assessed Chilean regions.

The first company, based in Santiago, reused post-consumer textiles and mechanically recycled both pre- and post-consumer. While the input material was sourced locally and did not directly involve imported goods, it is possible that post-consumer textiles were initially imported before their use in Chile. The recycling process at this facility avoided the emission of almost 6 tonnes of CO₂ eq per tonne of mixed textile waste, compared to landfilling [66]. The other example is a company in Alto Hospicio, which transforms textile waste into thermal and acoustic insulation panels. No data on avoided emissions were available for this specific case in Alto Hospicio. However, Islam [67] evaluated the environmental emissions associated with textile waste-based insulation panels and quantified that a panel weighing 0.80 kg, composed of 100% waste cotton, emits eleven and sixteen times fewer CO₂ eq emissions than conventional stone wool and flax-based insulation panels, respectively. Similarly, an insulation panel consisting of 90% waste cotton and 10% polylactic acid emits three and four times fewer CO₂ eq emissions than conventional stone wool and flax-based insulation panels, respectively [67].

A Methodology for Environmental Analysis of used Textile Trade in Importing Countries

Drawing on the experience gained in northern Chile, a methodology was devised to support the further progression of this case and enable comprehensive analyses of other importing countries (Table 1). While the methodology used in this study was rapid ethnography applied as a qualitative mixed-method approach, the proposed methodology here employs a qualitative and quantitative mixed-method approach. According to Morse [50], this represents the most challenging approach in mixed methods, “because mixing paradigms means that the researcher is using contradictory assumptions and rules for inquiry” [50, p.9]. In qualitative and quantitative mixed-method research, both qualitative and quantitative methods are integrated to address a single research question [50]. Considering the rationale behind the integration of these methods, as proposed by Greene et al. [68], the combination of quantitative and qualitative research methods in the proposed methodology is complementary. This integration “seeks elaboration, enhancement, illustration, clarification of the results from one method with the results from the other method” [68, p.259]. It is anticipated that a qualitative and quantitative mixed-method approach will yield more detailed and comprehensive insights [50], increase the interpretability and validity of results, and leverage the strengths of each method while counteracting biases inherent to each [68]. Consequently, the collection and analysis of both qualitative and quantitative data collection and analysis will allow for a more granular environmental assessment of the impacts used textile trade in importing countries.

Table 1 Methodology for environmental analysis of used textile trade in importing countries

Phase number	Key stakeholders or sites included ^a	Methods	Task	Expected outputs
Preliminary desk research				
1	-	<ul style="list-style-type: none">- Screening of national and global statistics- Review of peer-reviewed and grey literature	To examine available quantitative data of the importing country on: <ul style="list-style-type: none">- Textile production- Textile consumption- Textile waste generation- New textile trade- Used textile trade	<ul style="list-style-type: none">- Quantitative data about production, consumption and trade volumes- Initial contextual understanding- Identification and contact of key stakeholders
2	-	<ul style="list-style-type: none">- Screening of applicable legal frameworks- Review of media outlets and grey literature- Stakeholder analysis	To examine available information of the importing country on: <ul style="list-style-type: none">- Textile waste management and specific related policies- Geographical points of entry of used textiles- Major second-hand textile markets and recycling companies- Outstanding stakeholders within the used textiles value chain (local universities, NGOs, experts, and others)	
3	<ul style="list-style-type: none">- Local universities- NGOs- Local experts on the textile or second-hand textile industry, waste management, or circular economy- Local authorities- Other outstanding stakeholders	Emails exchange, calls and conversations with local universities, NGOs, experts and other detected outstanding stakeholders from last task in Phase 2	To reach key informants to: <ul style="list-style-type: none">- Engage with them, introduce the investigation, and get new insights and perspectives (insights from this task are expected to also contribute on tasks from Phase 1 and 2).- Foster collaborations for the fieldwork prior to travelling to the importing country.	
On-site fieldwork				
4	<ul style="list-style-type: none">- Importers- Second-hand retailers- Population	<ul style="list-style-type: none">- Interactive shadowing with importers, second-hand retailers and local population- Observational methods (observation, photography, videography...)	On-site contextual comprehension (1-2 weeks): <ul style="list-style-type: none">- Examination of the field of study- Visits- First in-person contact with multiple stakeholders <p>This phase resembles to the groundwork laid during this study in Chile.</p>	<ul style="list-style-type: none">- Used textiles value chain in the importing country- Stakeholders' experiences, perspectives, opinions, relationships, waste prevention strategies, etc. towards imported used textiles and government measures- Volumes of flows of used textiles- Indicators monitoring consumer practices and materials circularity- Characteristics of unsellable used textiles- Primary, corroborated, and high-quality data- Improved traceability of imported used textiles
5	<ul style="list-style-type: none">- Waste managers- Government and administration	<ul style="list-style-type: none">- Semi-structured interviews with waste managers and government representatives- Stakeholder analysis	To address aspects regarding textile waste management in the importing country and used textile trade such as: <ul style="list-style-type: none">- Current textile waste management system- Textile waste management options- Problems detected- Strategies being applied- Potential impact of import restrictions on the local community- Relevant data and indicators for the case study- Relationship with other stakeholders (importers, retailers, other countries...)	
6	<ul style="list-style-type: none">- Importers- Second-hand retailers	<ul style="list-style-type: none">- Semi-structured interviews with second-hand retailers and importers- Short questionnaires for second-hand retailers and importers	To gather insights on: <ul style="list-style-type: none">- Management strategies employed for unsold used textiles- Strategies to mitigate the accumulation of unsold used textiles- Potential impact of import restrictions on the local community- Relationship with other stakeholders (government, importers, retailers...) <p>To address the control and data knowledge of stakeholders about used textile flows via:</p> <ul style="list-style-type: none">- Quantities of purchases (mass and value)- Quantities of sales (mass and value)- Proportion of unsold used textiles- Characterization of unsold used textiles	
7 optional	- Population	Population surveying	To address diverse possible subjects such as: <ul style="list-style-type: none">- Population behaviour towards purchasing used textiles- Population behaviour towards disposing of textile waste- Population perception of textile waste- Population perception of used textile trade- Calculation of indicators (replacement rate, second-hand purchase ratio...)	
8 optional	<ul style="list-style-type: none">- Importers- Second-hand retailers- Circular economy-based initiatives	Waste composition analysis	To define unsellable used textiles in the importing country according to different characteristics: <ul style="list-style-type: none">- Quality- Garment / scrap type- Fibre material- Brand	
9	<ul style="list-style-type: none">- Ports- Dumpsites- Circular economy-based initiatives	<ul style="list-style-type: none">- Observational methods (observation, photography, videography...)- Informal interviews	To follow and trace the potential journeys of used textiles according to the information gathered in tasks from Phases 4 to 6. <p>To examine the variables of gender, age, social status and the distinction between formal and informal stakeholders through the whole system with special attention to importers and retailers.</p>	
Desk research				
10	-	Environmental data analysis: <ul style="list-style-type: none">- Material Flow Analysis (MFA)- Life Cycle Assessment (LCA)- Statistical analysis- Qualitative data analysis	Environmental analysis of all the information gathered using different methods typical from the Industrial Ecology and Social Research disciplines. Some findings may be translated into quantitative indicators when relevant. <p>This task may also imply putting together and comparing information from different importing countries if more than one country is examined.</p>	<ul style="list-style-type: none">- Quantification of material flows, environmental impacts, and environmental and circularity indicators.- Figures regarding stakeholder practices and used textiles characteristics- Scientific data about the traceability of used textiles- Scientific data to support informed decision-making

Table 1 (continued)

¹Coloured stakeholders and sites are those that have already been examined as part of the used textiles value chain and have contributed insights for this work. Each colour corresponds to a stakeholder or site of the used textiles value chain, as presented in Fig. 1. Black colour stakeholders and sites are those not considered in this study but are suggested to be addressed in the proposed framework

The proposed methodology consists of two main phases, mirroring the approach used in this study (Table 1): preliminary desk research on the target country, followed by on-site fieldwork within the same country. A final desk research phase is added for data analysis. Following, the phases are explained:

- Preliminary desk research. The expected outputs include quantitative data on the production, consumption, and trade volumes of new and used textiles, an initial conceptual understanding of the situation and context, and the identification and contact of key stakeholders. The quantitative data will be relevant for both fieldwork (Phases 4 to 9) and, particularly, for subsequent desk research involving data analysis (Phase 10). Qualitative data will facilitate the initial understanding of the assessed country and stakeholders and is of utmost importance for the fieldwork. These expected outcomes will be achieved through a series of tasks organised into distinct phases:

Phase 1. Research on the target country is especially relevant in the context of international research [49]. This preliminary desk research will take approximately six weeks. It will involve examining available quantitative data on textile production, consumption, waste generation, and both new and used textile trade. Relevant secondary data will be sourced from national and global statistics, as well as peer-reviewed and grey literature.

Phase 2. Additionally, preliminary desk research will entail a general screening of textile waste management policies of the country under study and other pertinent legal frameworks. Media outlets and grey literature will be reviewed to identify key entry points for used textiles, major second-hand textile markets, and outstanding stakeholders within the used textiles value chain. Additionally, outstanding stakeholders will be identified, differentiated, and categorised following methods from the stakeholder analysis typology proposed by Reed et al. [69].

Phase 3. Furthermore, the preliminary research will involve engaging with previously identified key informants and establishing collaborations with local universities, NGOs, and other experts. Fostering such collaborations is crucial to facilitate clear communication and mutual language-based understanding with stakeholders. In this study, it was identified that the manner in which stakeholders are approached, engaged with, and understood is a critical aspect to consider. Previous studies also highlighted this issue [49, 70].

- On-site fieldwork. The expected outputs include both qualitative and quantitative data regarding stakeholders' knowledge, opinions, and practices, as well as the quantification of flows of imported used textiles. The data gathered will be primary, corroborated, and of high quality and will contribute to textile waste management by. These expected outcomes will be achieved through a series of tasks organised into distinct phases:

- Phase 4. The subsequent fieldwork in the importing country will leverage conventional ethnographic research methods to support the qualitative part of the mixed-method analysis. The initial 1–2 weeks will be dedicated to gaining on-site contextual understanding and establishing initial in-person contacts. This will involve interactive shadowing with importers, second-hand retailers, and members of the local population. This phase mirrors the entire fieldwork conducted in this preliminary study in Chile. However, the proposed methodology expands and deepens this fieldwork (via Phases 5 to 9) to allow for a more comprehensive assessment of the environmental impacts associated with the used textile trade.
- Phase 5. It will involve conducting semi-structured interviews with local waste managers and government representatives. This method allows for flexibility in the phrasing and order of questions across various contextual settings, while still generating sufficiently comparable data [49]. Similar studies have utilised interviews with government officials and policymakers [14, 15, 17]. In the proposed methodology, semi-structured interviews will focus on textile waste management and used textile trade, and relationships and interactions between stakeholders. The latter aspect will also be investigated through the methods of stakeholder analysis proposed by Reed et al. [69]. This task is relevant for providing qualitative data to be further analysed in Phase 10. Additionally, interviews may support the identification of context-specific environmental and circular indicators to be calculated during the environmental analysis conducted in of Phase 10.
- Phase 6. Semi-structured interviews and short questionnaires will be conducted with both second-hand retailers and importers. Similarly to Phase 5, these interviews are particularly suitable in the context of this proposal due to the diversity of contexts and stakeholders involved. They ensure that the data collected remains comparable and help in identifying trends. Similar studies have also employed interviews with business owners [14], informal retailers [17], and sorters [17, 38]. Interviews have also been used for data quantification [38], while surveys have been conducted with the mentioned stakeholders as well [15, 17]. In this methodology, semi-structured interviews will explore strategies related to waste prevention, the impact of the legal framework and restrictions on businesses, and the relationship between different stakeholders. The semi-structured interviews will be complemented with short questionnaires to capture the control and knowledge these stakeholders have over the used textile flows they engage with. This will enable the efficient collection of quantitative data on the volumes and economic value of the textile flows they manage, providing valuable data for subsequent environmental analysis (Phase 10) through MFA.
- Phase 7. Population surveys will be optionally employed for more in-depth studies. These surveys will provide insights into consumer behaviour regarding the purchase of used textiles (e.g., second-hand clothing) and public perceptions of the used textile trade. They will facilitate qualitative and quantitative data collection and the calculation of specific indicators. Population surveys were employed by Nørup et al. [36] in Malawi, Mozambique, and Angola to calculate replacement rates for second-hand clothing. Collaborating with a local university could be advantageous for this phase.

Phase 8. A waste composition analysis of unsellable used textiles will be optionally conducted for more comprehensive studies. This analysis will serve to identify the key characteristics of unsellable used textiles. The data generated during this phase, will be key for the development of an MFA, an LCA, as well as for calculating indicators such as reuse and recyclability rates during Phase 10. Moreover, the information gathered will be crucial for refining sorting and export criteria in exporting countries, as well as mitigating textile waste generation in importing countries resulting from unsellable used textiles. Previous composition analyses of used textiles were done in exporting countries [71–73], with few references found from importing countries [58]. Collaborating with a local university could be advantageous for this phase.

Phase 9. Tasks from this phase are expected to overlap with those from Phases 5, 6, and 7. Phase 9 will consist of tracing all gathered information by following the identified pathways of used textiles within the examined importing country. This will be accomplished through observational methods and additional informal interviews, building on the data gathered during Phases 4 to 6. Data collection on gender, age, social status, and the distinction between formal and informal stakeholders within the sector will also be conducted in this phase. These variables will be examined across the entire system, with a particular focus on importers and retailers. This will be explored through observational methods and during the interviews with various stakeholders.

- Desk research. Finally, all gathered data will be environmentally analysed in desk-based research as part of Phase 10 (Table 1, Phase 10). This analysis will employ methods such as MFA, LCA, statistical analysis, and qualitative analysis to: quantify material flows and environmental impacts using data obtained in Phases 1, 6, and 8; generate environmental and circularity indicators, such as replacement rate, recyclability potential, material circularity, and waste generation, drawing on data collected in Phases 5, 7, and 8; and generate figures regarding stakeholder practices and used textiles characteristics based on data from Phases 4, 6, 8, and 9. All this information will define the environmental sustainability of imported used textiles and support the monitoring of progress towards a more sustainable management of used textiles. Furthermore, this information will provide scientific evidence regarding the traceability of used textiles and inform evidence-based decision-making and policy development at both national and regional levels, for both importing and exporting countries.

One of the novelties of the proposed framework lies in the design and inclusion of new phases (i.e., Phases 5 to 10). The environmental analysis conducted in Phase 10 relies primarily on data generated in these newly introduced phases. This highlights the added value of the improved framework for assessing the environmental sustainability of imported used textiles. The other novelty of the proposed methodology is the integration of stakeholder involvement and a social perspective within an environmental assessment. Participatory approaches have previously been recognized as valuable components in environmental assessments [74, 75]. For instance, Whitfield & Reed [74], emphasised that this “is an approach to environmental assessment that is sensitive to the needs and experience of present and future stakeholders and creates potential avenues for co-operative management deci-

sions and socially-acceptable policies” [74, p.1]. As such, the inclusion of this participatory dimension is considered a particularly valuable contribution of the proposed methodology.

Moreover, the proposed methodology aims to address several of the limitations identified during the course of this study. The perspective of the local government and administration was gathered through desk research, but it would be advisable to explore the actions and perspectives concerning imported used textiles and textile waste management by direct communication. This is incorporated in the proposed methodology to gain direct insight into their stance on used textile trade and textile waste management within the territory under study. This will be achieved through Phases 2 and 4 of the proposed methodology.

Additionally, the study was entirely qualitative, with no integration of quantitative data collection or analysis. The interpretation of solely qualitative results was already noted as a limitation in a similar study “as the empirical findings are unintentionally and inevitably influenced by the researcher’s perception and personal bias” [25, p.18]. To address this, the proposed mixed-method approach combines qualitative and quantitative research. According to Bryman [76], this integration enhances the research process by facilitating smoother access to research sites and providing insight into both structural and processual features. Quantitative methods will also be essential for calculating relevant metrics and helping in the interpretation of results. Quantitative research within the proposed mixed-method approach will be addressed in Phases 1, 6, 7, and 8.

Another limitation that may introduce potential biases and reduce transparency is the absence of demographic variables for the interviewed stakeholders. Therefore, in the proposed methodology, the analysis of interviewed and observed stakeholders will include a more detailed consideration of demographic variables, such as gender, social status, age, and the distinction between formal and informal stakeholders. This will be implemented as a task from Phase 9.

Finally, limited collaboration with local stakeholders prior to the fieldwork may have resulted in a partial understanding of the cultural context. The limited depth of exploration is a typical limitation of studies constrained by time and resources, such as rapid ethnography [48]. However, collaboration with local researchers from universities is expected to foster a deeper understanding of the cultural context. Such collaborations should be established prior to or during the preliminary desk research and maintained throughout all phases of the project. Similarly, collaborations with local researchers and NGOs are expected to help overcome language barriers. Although this study did not encounter such a barrier, as Spanish was the primary language of both the researcher and the community studied, previous studies have mentioned the influence of language in research [25].

Considering that research plays a pivotal role in the development and acceptance of policies by providing crucial evidence for informed decision-making [77], the use of the proposed methodological framework offers significant environmental and social benefits. The outputs derived from applying the proposed methodology are expected to support decision-making processes, identify critical aspects for action, and offer evidence for informed policy making that protects both the environment and the health and wellbeing of local communities and small businesses. The trade of used textiles represents a complex issue with economic, social, and environmental advantages and disadvantages. Consequently, policies must address the negative impacts of these practices while striving to preserve their benefits. This requires a comprehensive and systemic understanding of the local context and the specific needs of the communities involved. The proposed methodology represents an initial

step towards facilitating this understanding. The implementation of this methodology can provide greater control and insight into the flows of imported used textiles, how they are managed, where they ultimately end up, and how various stakeholders interact with these flows. Only in this way can environmental impacts be mitigated while ensuring that no adverse social or economic consequences arise.

Conclusions

This study examines the value chain for used textiles in Chile as a case study. The research specifically focuses on two key regions: the Tarapacá Region and the Santiago Metropolitan Region. The adopted methodology included interactive shadowing and observational techniques, as a multi-method approach within the framework of rapid ethnography. This methodology facilitated the effective mapping of the value chain of imported used textiles in Chile and provided key insights to develop an improved methodological framework for environmentally assessing imported used textiles.

The findings from the value chain examination reveal that used textiles enter the country via ports. Then, importer companies and retailers sell them as second-hand textiles. Valuable local initiatives promote textile waste prevention through circular economy models based on the reuse, recycling, and downcycling of pre- and post-consumer textiles. However, a portion of used textiles ends up as waste in dumpsites, because not all imported used textiles intended for reuse and recycling are effectively commercialised or utilised in Chile.

From this examination, unusable and unsellable textiles, typically of low quality, along with their waste management, are identified as the main environmental issue related to imported used textiles for the importing country. This represents a systematic problem, summarised as follows: (1) there is a continuous accumulation of low-quality used textiles entering the country, primarily through unsorted bales, (2) low-quality used textiles end up as waste, sooner or later, within the importing country, and (3) there is lack of textile waste management alternatives in the importing country. Moreover, this issue is worsened by low-quality used textile flows being unknown and untraceable.

As a result, three main pressing needs are identified. First, the sorting and quality criteria for exported used textiles must be improved, especially for those of lower quality. Second, legislation and viable alternatives for textile waste management in importing countries need to be enhanced to mitigate the negative impacts associated with surplus used textiles of low quality. Finally, the flow of used textiles needs to be traced, and comprehensive data about this must be shared.

The examination of the value chain of imported used textiles provided insights for enhancing and extending the applied methodology. Thus, an improved qualitative and quantitative mixed-method approach is proposed to environmentally assess used textile trade in importing countries worldwide. This method consists of ten phases. It recommends the use of semi-structured interviews, supplemented by methods of stakeholder analysis, interactive shadowing, informal interviews, waste composition analyses, and traditional ethnographic methods like surveys, questionnaires, and observation techniques, for data collection. The application of MFA, LCA, statistical analysis, and qualitative data analysis are recommended for the environmental assessment. The proposed mixed-method approach integrates stakeholder involvement and a social perspective into the environmental assessment.

It also enhances the traceability of used textiles and provides primary, corroborated, and high-quality data on imported used textile flows. These outcomes are expected to improve the understanding of environmental dynamics and support decision-making processes.

In conclusion, this study underscores the urgent need for comprehensive research on the used textiles value chain and the traceability of imported used textile flows. Future research should address data gaps and develop more exhaustive studies, including all stakeholder perspectives. This study advocates for methodologies that consider both the positive and negative impacts of the global used textile trade, particularly focusing on those in importing countries. Additionally, it calls for consideration of the interrelationships between stakeholders to help gain a more precise understanding of the main textile waste generators. This study advocates for a quality standard to improve the sorting and exporting criteria of used textiles, considering their quality. Such standard should ensure traceability, thereby improving the accounting of trade flows and mitigating environmental impacts in importing countries, particularly those generated by unsorted and low-quality used textiles.

Acknowledgements This work was supported by the “María de Maeztu” program for Units of Excellence in R&D [CEX2019-000940-M]. The authors would also acknowledge the “Agència de Gestió d’Ajuts Universitaris i Recerca” from the Catalan Government and the “Departament de Recerca i Universitats” for the funding received for Sostenipra Research Group number 2021SGR00734. The project that gave rise to these results received the support of a fellowship from the “la Caixa” Foundation (ID 100010434). The fellowship code is LCF/BQ/DR23/12000032. It also received the support of the Talent UAB Santander program. The study received support from the Sino-Dutch project “Towards Inclusive CE: Transnational Network for Wise-waste Cities (IWWCs)” which is one of the projects of the Erasmus Initiative Dynamics of Inclusive Prosperity, and it is co-funded by the Dutch Research Council (NWO) and the National Natural Science Foundation of China (NSFC); NWO project number: 482.19.608; NSFC project number: 72061137071.

Author Contributions Gemma Morell-Delgado: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing—Original Draft, Writing—Review & Editing, Visualization, Project administration, Funding acquisition. Laura Talens Peiró: Conceptualization, Validation, Writing—Review & Editing, Supervision, Funding acquisition. Susana Toboso-Chavero: Conceptualization, Validation, Writing—Review & Editing, Supervision, Funding acquisition.

Funding Open Access Funding provided by Universitat Autònoma de Barcelona.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

1. Ellen MacArthur Foundation (2017) A new textiles economy: Redesigning fashion's future. <https://content.ellenmacarthurfoundation.org/m/6d5071bb8a5f05a2/original/A-New-Textiles-Economy-Redesigning-fashions-future.pdf>
2. International Organization for Standardization (2023) Textiles — environmental aspects — vocabulary (ISO Standard No. 5157:2023). <https://www.iso.org/standard/80937.html>. Accessed 11 Nov 2024
3. Huygens D, Foschi J, Caro D et al (2023) Techno-scientific assessment of the management options for used and waste textiles. <https://doi.org/10.2760/6292>
4. European Parliament, Council of the European Union (2008) Directive 2008/98/EC of the European parliament and of the council of 19 november 2008: on waste and repealing certain Directives. Off J Eur Union 3–30. <https://data.europa.eu/eli/dir/2008/98/oj>. Accessed 13 Dec 2024
5. European Environment Agency (2024) Management of used and waste textiles in Europe's circular economy. <https://www.eea.europa.eu/publications/management-of-used-and-waste-textiles>. Accessed 7 Nov 2024
6. Morell-Delgado G, TalensPeiró L, Toboso-Chavero S (2024) Revealing the management of municipal textile waste and citizen practices: The case of Catalonia. *Sci Total Environ* 907:168093. <https://doi.org/10.1016/j.scitotenv.2023.168093>
7. Brady S, Lu S (2018) Why is the used clothing trade such a hot-button issue? <https://shenglufashion.com/2018/11/15/why-is-the-used-clothing-trade-such-a-hot-button-issue/>. Accessed 19 Sep 2024
8. Watson D, Nielsen R, Palm D et al (2016) Exports of nordic used textiles. Nordic Council of Ministers. <https://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A1057017&dsid=-7948>. Accessed 11 Oct 2024
9. Simoes AJG, Hidalgo CA (2011) The economic complexity observatory: an analytical tool for understanding the dynamics of economic development. In: Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence, pp 39–42. <https://static1.squarespace.com/static/5759bc7886db431d658b7d33/t/5c6e037f9140b7a9ae975475/1550713737915/SimoesHidalgo.pdf>. Accessed 19 Sep 2025
10. Lingås D, Manshoven S, Fogh Mortensen L, Paulsen F (2023) ETC CE Report 2023/4 EU exports of used textiles in Europe's circular economy. <https://www.eionet.europa.eu/etcs/etc-ce>. Accessed 25 Sep 2024
11. Circle Economy (2023) Destinations of dutch used textiles: uses and risks after export. <https://www.circle-economy.com/resources/destinations-of-dutch-used-textiles>. Accessed 25 Sep 2024
12. Quashie-Idun S (2024) Fast fashion, slow poison: the toxic textile crisis in Ghana. https://www.greenpeace.org/static/planet4-africa-stateless/2024/09/925601ff-fastfashionslowpoison_reportbygreenpeace.pdf. Accessed 25 Sep 2024
13. Paúl F (2022) “Hemos transformado nuestra ciudad en el basurero del mundo”: el inmenso cementerio de ropa usada en el desierto de Atacama en Chile. In: BBC News. <https://www.bbc.com/mundo/noticias-america-latina-60024852>. Accessed 26 Sep 2024
14. Brunello L, Palomo L, O'Brien B et al (2024) Reversing direction in the used clothing crisis: global, European and Chilean perspectives. <https://hdl.handle.net/11362/80433>. Accessed 27 Sep 2024
15. Branson Skinner J (2019) Fashioning waste: considering the global and local impacts of the secondhand clothing trade in Accra, Ghana and charting an inclusive path forward. <https://www.proquest.com/openview/eb2e2c43f60b73055c97cb9818edb664/1?pq-origsite=gscholar&cbl=18750&diss=y>. Accessed 11 Oct 2024
16. Odonkor S (2024) An evaluation of the socio-economic and environmental impact of the second-hand clothes trade in Ghana. <https://www.humanaitalia.org/wp-content/uploads/2024/10/240514-Ghana-Evaluation-of-the-Socio-Economic-and-Environmental-Impact-of-the-Second-Hand-Clothes-Trade.pdf>. Accessed 11 Oct 2024
17. Oxford Economics (2024) The socio-economic impact of second-hand clothes in Africa and the EU27+. https://assets.foleon.com/eu-central-1/de-uploads-7e3kk3/50837/impact_of_secondhand_clothes_in_africa_and_eu.abda1f622b36.pdf. Accessed 11 Oct 2024
18. Mensah J (2023) The Global South as a Wasteland for Global North's fast fashion: Ghana in focus. <https://doi.org/10.11648/j.ajbes.20230903.12>
19. European Commission (2014) 2014/955/EU: Commission decision of 18 december 2014: amending decision 2000/532/EC on the list of waste pursuant to directive 2008/98/EC of the European Parliament and of the Council. Off J Eur Union 44–86. <https://data.europa.eu/eli/dec/2014/955/oj>. Accessed 13 Dec 2024
20. Feyertag J (2024) Job creation in Africa's second-hand clothing sector. <https://www.humana.org/images/publications/job-creation.pdf>. Accessed 19 Sep 2024

21. Baden S, Barber C (2005) The impact of the second-hand clothing trade on developing countries. <https://policy-practice.oxfam.org/resources/the-impact-of-the-second-hand-clothing-trade-on-developing-countries-112464/>. Accessed 9 Oct 2024
22. Patwary SU (2020) An investigation of the substitution rate and environmental impact associated with secondhand clothing consumption in the United States. Kansas State University. <https://www.proquest.com/openview/8aaf1c98631c00f00071665a345e5a76/1?pq-origsite=gscholar&cbl=51922&diss=y>. Accessed 19 Sep 2024
23. Farrant L, Olsen SI, Wangel A (2010) Environmental benefits from reusing clothes. *Int J Life Cycle Assess* 15:726–736. <https://doi.org/10.1007/s11367-010-0197-y>
24. Semba T, Sakai Y, Ishikawa M, Inaba A (2020) Greenhouse gas emission reductions by reusing and recycling used clothing in Japan. *Sustainability* 12:8214. <https://doi.org/10.3390/su12198214>
25. Mayer V (2024) Power relations within the second-hand clothing industry touching down in Ghana. *ÖFSE-Forum*, No. 88. <https://www.econstor.eu/bitstream/10419/305264/1/190680091X.pdf>. Accessed 12 Nov 2024
26. Bartlett J (2023) Fast fashion goes to die in the world's largest fog desert. *Natl Geogr Mag*. <https://www.nationalgeographic.es/medio-ambiente/2024/03/es-ser-un-soldador-submarino-el-oficio-mas-peligroso-del-mundo>. Accessed 27 Sep 2024
27. Johnson S (2024) Castoffs to catwalk: fashion show shines light on vast Chile clothes dump visible from space. *The Guardian*. <https://www.theguardian.com/global-development/article/2024/may/08/castoffs-to-catwalk-fashion-show-shines-light-on-vast-chile-clothes-dump-visible-from-space>. Accessed 26 Sep 2024
28. Johnson S (2023) 'It's like a death pit': how Ghana became fast fashion's dumping ground. *The Guardian*. <https://www.theguardian.com/global-development/2023/jun/05/yvette-yaa-konadu-tetteh-how-ghana-became-fast-fashions-dumping-ground>. Accessed 26 Sep 2024
29. Besser L (2021) Dead white man's clothes. *ABC News*. <https://www.abc.net.au/news/2021-08-12/fast-fashion-turning-parts-ghana-into-toxic-landfill/100358702>. Accessed 26 Sep 2024
30. Tondo M (2023) A third of all second-hand clothing shipped to Kenya is plastic waste in disguise. *Lampoon*. <https://lampoonmagazine.com/article/2023/10/27/kenya-second-hand-clothing-market-textile-waste-plastic-pollution/>. Accessed 9 Oct 2024
31. Koligkioni A, Parajuly K, Sørensen BL, Cimpan C (2018) Environmental assessment of end-of-life textiles in Denmark. *Procedia CIRP* 69:962–967. <https://doi.org/10.1016/j.procir.2017.11.090>
32. Millward-Hopkins J, Purnell P, Baurley S (2023) Scenarios for reducing the environmental impacts of the UK clothing economy. *J Clean Prod* 420:138352. <https://doi.org/10.1016/j.jclepro.2023.138352>
33. Bekkevold Lingås D, Mailund Rebsdorf J (2024) Sorting criteria for second hand clothes to Kenya. <https://handelensmiljofond.ams3.digitaloceanspaces.com/reports/Sorting-criteria-for-second-hand-clothes-to-kenya.pdf>. Accessed 10 Oct 2024
34. Cobbing M, Daaji S, Kopp M, Wohlgemuth V (2022) Poisoned Gifts. From donations to the dumpsite: textiles waste disguised as second-hand clothes exported to East Africa. https://es.greenpeace.org/es/wp-content/uploads/sites/3/2022/04/220421_S03961_gp_poisoned_gifts_factsheet_en07.pdf. Accessed 16 Dec 2024
35. Wang J, Wang R (2024) Second-hand clothing markets: an overview in Uganda and the United Republic of Tanzania. https://unctad.org/system/files/non-official-document/-smep-shc_19-11-2024-2-2.pdf. Accessed 16 Dec 2024
36. Nørup N, Pihl K, Damgaard A, Scheutz C (2019) Replacement rates for second-hand clothing and household textiles – a survey study from Malawi, Mozambique and Angola. *J Clean Prod* 235:1026–1036. <https://doi.org/10.1016/j.jclepro.2019.06.177>
37. Manieson LA, Ferrero-Regis T (2023) Castoff from the West, pearls in Kantamanto? A critique of second-hand clothes trade. *J Ind Ecol* 27:811–821. <https://doi.org/10.1111/jiec.13238>
38. Ellen MacArthur Foundation (2024) Pushing the boundaries of EPR policy for textiles. <https://content.ellenmacarthurfoundation.org/m/25149f10b584fe49/original/Pushing-the-boundaries-of-EPR-policy-for-textiles.pdf>. Accessed 10 Oct 2024
39. Corvo L, Pastore L, Manti A, Iannaci D (2021) Mapping Social Impact Assessment Models: A Literature Overview for a Future Research Agenda. *Sustainability* 13:4750. <https://doi.org/10.3390/su13094750>
40. Ministerio de Hacienda (2001) Decreto con Fuerza de Ley 2. Aprueba el texto refundido, coordinado y sistematizado del Decreto con Fuerza de Ley n°341, de 1977, del Ministerio de Hacienda, sobre zonas francas. Chile. <https://www.bcn.cl/leychile/navegar?i=188367&f=2020-03-01>. Accessed 11 Oct 2024
41. Bartlett J (2023) Fast fashion goes to die in the world's largest fog desert. *Natl Geogr Mag*. <https://www.nationalgeographic.com/environment/article/chile-fashion-pollution>. Accessed 27 Sep 2024
42. Shipley J, Alarcón M (2024) Burn after wearing. In: *Grist*. <https://grist.org/international/burn-after-wearing-fashion-waste-chile/>. Accessed 27 Sep 2024

43. Genzuk M (Fall, 2003) A synthesis of ethnographic research. Center for multilingual, multicultural research, Rossier School of education, University of Southern California, Los Angeles. https://web-app.usc.edu/web/rossier/publications/33/Ethnographic_Research.pdf. Accessed 1 Oct 2024
44. Blomberg J, Burrell M (2012) An ethnographic approach to design, pp 1025–1052. https://www.researchgate.net/publication/262363851_An_Ethnographic_Approach_to_Design. Accessed 1 Oct 2024
45. Sandhu JS, Altankhuyag P, Amarsaikhan D (2007) Serial hanging out: rapid ethnographic needs assessment in rural settings. In: Jacko JA (ed) Human-Computer Interaction. Interaction Design and Usability. HCI 2007. Lecture Notes in Computer Science. Springer, Berlin, Heidelberg, pp 614–623. https://doi.org/10.1007/978-3-540-73105-4_68
46. Millen DR (2000) Rapid ethnography: time deepening strategies for HCI field research. In: Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques. ACM, New York, NY, USA, pp 280–286. <https://doi.org/10.1145/347642.34776>
47. Westphal LM, Hirsch JL (2010) Engaging Chicago residents in climate change action: results from rapid ethnographic inquiry. *Cities Environ* 3:13. <https://digitalcommons.lmu.edu/cate/vol3/iss1/13>
48. Sangaramoorthy T, Kroeger KA (2020) Rapid ethnographic assessments. Routledge
49. Halme M, Kourula A, Lindeman S et al (2016) Sustainability innovation at the base of the pyramid through multi-sited rapid ethnography. *Corp Soc Responsib Environ Manag* 23:113–128. <https://doi.org/10.1002/csr.1385>
50. Morse JM (2009) Mixed method design: principles and procedures, 1st edn. Routledge, New York
51. Bryman A (2012) Social research methods, 4th edn. Oxford University Press
52. Gobierno de Chile (2024) Estadísticas Comercio Exterior Chileno (COMEX). In: Chile Aduanas Customs. <https://www.aduana.cl/aduana/site/edic/base/port/comex.html#>. Accessed 30 Sep 2024
53. Mundo Marítimo (2024) Puertos de Chile movilizaron un total de 61,3 millones de toneladas de exportación y 56,1 de importación en 2022. <https://www.mundomaritimo.cl/noticias/puertos-de-chile-movilizaron-un-total-de-613-millones-de-toneladas-de-exportacion-y-561-de-importacion-en-2022>. Accessed 2 Oct 2024
54. Google (2024a) Google maps directions for driving from “Puerto de Iquique - Avenida Arturo Prat, Iquique, Tarapacá, Chile” to “Santiago, Santiago Metropolitan Region, Chile.” https://www.google.es/maps/dir/Puerto+de+Iquique+-+Avenida+Arturo+Prat,+Iquique,+Xile/Santiago+de+Xile,+Regi/C3/B3+Metropolitana+de+Santiago,+Xile/@-26.7303349,-76.1370913,2121049m/data=!3m2!1e3!4b1!4m14!4m13!1m5!1m1!1s0x9152115ab8c6bb3b:0x7c19e1945164f640!2m2!1d-70.158232!2d-20.2069509!1m5!1m1!1s0x9662c5410425af2f:0x8475d53c400f0931!2m2!1d-70.6692655!2d-33.4488897!3e0?hl=en&entry=ttu&_ep=EgoyMDI0MDkyOS4wIKXMDSoASAFQAw/3D/3D. Accessed 2 Oct 2024
55. Google (2024b) Google maps directions for driving from “Puerto San Antonio - Antonio Núñez de Fonseca 1552, 2660000 Valparaíso, San Antonio, Valparaíso, Chile” to “Santiago, Santiago Metropolitan Region, Chile.” https://www.google.es/maps/dir/Puerto+San+Antonio+-+Antonio+N/C3/BA/C3/B1ez+de+Fonseca,+Valpara/C3/ADso,+San+Antonio,+Chile/Santiago+de+Xile,+Regi/C3/B3+Metropolitana+de+Santiago,+Xile/@-33.5245488,-71.4704596,123737m/data=!3m2!1e3!4b1!4m14!4m13!1m5!1m1!1s0x966239f610c0e0cd:0xb309ee483d85b953!2m2!1d-71.6267547!2d-33.574501!1m5!1m1!1s0x9662c5410425af2f:0x8475d53c400f0931!2m2!1d-70.6692655!2d-33.4488897!3e0?hl=en&entry=ttu&_ep=EgoyMDI0MDkyOS4wIKXMDSoASAFQAw/3D/3D. Accessed 2 Oct 2024
56. Alarcón M, Shipley J (2024) Las montañas de ropa se esfumaron del desierto de Atacama, pero el problema no desapareció. *El País*. <https://elpais.com/america-futura/2024-01-04/las-montanas-de-ropa-se-esfumaron-del-desierto-de-atacama-pero-el-problema-no-desaparecio.html>. Accessed 11 Oct 2024
57. Osterling Dankers EA, González Pavicich C (2020) La Quebradilla de Alto Hospicio: Relatos de comercio, oportunidades y ciudad. https://www.researchgate.net/publication/345439699_LA_QUEBRADILLA_DE_ALTO_HOSPICIO_RELATOS_DE_COMERCIO_OPORTUNIDADES_Y_CIUADAD#fullTextFileContent. Accessed 13 Dec 2024
58. Quashie-Idun S (2024) 8. Annex to fast fashion, slow poison: the toxic textile crisis in Ghana. <https://www.greenpeace.org/static/planet4-africa-stateless/2024/08/7f4fb6d8-ghana-textile-report-annex.pdf>. Accessed 13 Dec 2024
59. Ellen MacArthur Foundation (2024) Pushing the boundaries of EPR policy for textiles: Chile factsheet. <https://content.ellenmacarthurfoundation.org/m/2eed8caddac7191/original/Pushing-the-boundaries-of-EPR-policy-for-textiles-Chile-factsheet.pdf>. Accessed 10 Oct 2024
60. Google (2024c) Google maps directions for driving from “Feria La Quebradilla. ARgames - Los Tumbos 2839, Alto Hospicio, Tarapacá, Chile” to “20°12'15.8"S 70°02'46.4"W”. https://www.google.com/maps/dir/Feria+La+Quebradilla.+ARgames+-+Los+Tumbos+2839,+Alto+Hospicio,+Tarapac/C3/A1,+Xile/Alto+Hospicio,+Tarapac/C3/A1,+Chile/@-20.2249509,-70.0968385,9287m/data=!3m1!1e3!4m14!4m13!1m5!1m1!1s0x915214f4f532c89:0xc36069f10b58c256!2m2!1d-70.1064688!2d-20.2627149!1m5!1m1!1s0x91523e0056171ed9:0x8a71d9de0e7fbb2!2m2!1d-70.0466926!2d-20.2048014!3e0?hl=en&entry=ttu&_ep=EgoyMDI0MTAwMS4wIKXMDSoASAFQAw/3D/3D. Accessed 4 Oct 2024

61. Google (2024d) Google maps directions for driving from “ZOFRI, Iquique, Tarapacá, Chile” to 20°12'15.8"S 70°02'46.4"W". https://www.google.com/maps/dir/ZOFRI++ZOFRI,+Iquique,+Chile/Alto+Hospicio,+Tarapac%C3%A1,+Chile/@-20.2453317,-70.1341513,18571m/data=!3m2!1e3!4b!14m14!4m13!1m5!1m1!1s0x915216ae7c232801:0x7f04eaa137f1eb99!2m2!1d-70.139211!2d-20.205181!1m5!1m1!1s0x91523e0056171ed9:0x8a71d9de0e7fbb2!2m2!1d-70.0466926!2d-20.2048014!3e0?hl=en&entry=tu&g_ep=EgoyMDI0MTAwMS4wLWIKXMDSoASAFQAw/3D/3D. Accessed 4 Oct 2024
62. Primer Tribunal Ambiental (2022) Ingres a demanda por daño ambiental en contra del Fisco y de la Municipalidad de Alto Hospicio por vertederos ilegales en el desierto. In: Primer Tribunal Ambiental. República de Chile. <https://www.1ta.cl/ingresa-demanda-por-dano-ambiental-en-contra-del-fisco-y-de-la-municipalidad-de-alto-hospicio-por-vertederos-ilegales-en-el-desierto/>. Accessed 16 Dec 2024
63. Vergara SE, Damgaard A, Gomez D (2016) The efficiency of informality: quantifying greenhouse gas reductions from informal recycling in Bogotá, Colombia. *J Ind Ecol* 20:107–119. <https://doi.org/10.1111/jieec.12257>
64. AFP [@afpphoto] (2021) [AFP Photo @martinbernetti_photjournalist - Chile's desert dumping ground for fast fashion leftovers -]. https://www.instagram.com/p/CWQIZWUrqbx/?utm_source=ig_embed&ig_rid=2980645f-9c7b-4bbe-bfda-abd1ff916ae0&img_index=1. Accessed 4 Oct 2024
65. Bernetti M [@martinbernetti_photjournalist] (2021) [View of used clothes discarded in the Atacama desert, in Alto Hospicio, Iquique, Chile, on September 26, 2021]. https://www.instagram.com/p/CWBB13xL_QW/?img_index=1. Accessed 4 Oct 2024
66. Espinoza Pérez LA, Espinoza Pérez AT, Vásquez ÓC (2022) Exploring an alternative to the Chilean textile waste: A carbon footprint assessment of a textile recycling process. *Sci Total Environ* 830:154542. <https://doi.org/10.1016/j.scitotenv.2022.154542>
67. Islam S (2021) Processing, structure, and properties of recycled textiles into insulation materials. Graduate Faculty of The University of Georgia. <https://openscholar.uga.edu/record/4744?ln=en&v=pdf>. Accessed 18 Dec 2024
68. Greene JC, Caracelli VJ, Graham WF (1989) Toward a conceptual framework for mixed-method evaluation designs. *Educ Eval Policy Anal* 11:255–274. <https://doi.org/10.3102/01623737011003255>
69. Reed MS, Graves A, Dandy N et al (2009) Who's in and why? A typology of stakeholder analysis methods for natural resource management. *J Environ Manage* 90:1933–1949. <https://doi.org/10.1016/j.jenvman.2009.01.001>
70. Korsunova A, Halme M, Kourula A et al (2022) Necessity-driven circular economy in low-income contexts: How informal sector practices retain value for circularity. *Glob Environ Chang* 76:102573. <https://doi.org/10.1016/j.gloenvcha.2022.102573>
71. Weber S, Weber O, Habib K, Dias GM (2023) Textile waste in Ontario, Canada: Opportunities for reuse and recycling. *Resour Conserv Recycl* 190. <https://doi.org/10.1016/j.resconrec.2022.106835>
72. Refashion (2023) Characterisation study of the incoming and outgoing streams from sorting facilities - Summary Report. https://pro.refashion.fr/sites/default/files/rapport-etude/Overview_Characterisation_study_Refashion_2023_EN.pdf. Accessed 16 Dec 2024
73. Maldini I, Duncker L, Bregman L et al (2017) Measuring the Dutch clothing mountain: data for sustainability-oriented studies and actions in the apparel sector. https://pure.hva.nl/ws/portalfiles/portal/3144178/Measuring_the_Dutch_Clothing_Mountain_final_report_002_.pdf. Accessed 16 Dec 2024
74. Whitfield S, Reed MS (2012) Participatory environmental assessment in drylands: Introducing a new approach. *J Arid Environ* 77:1–10
75. Hisschemöller M, Tol RSJ, Vellinga P (2001) The relevance of participatory approaches in integrated environmental assessment. Kluwer Academic Publishers
76. Bryman A (2017) Quantitative and qualitative research: further reflections on their integration. In: *Mixing Methods: Qualitative and Quantitative Research*. Routledge, pp 57–78
77. Howlett M (2019) *Designing public policies: Principles and instruments*, Second Edition. Routledge. <https://doi.org/10.4324/9781315232003>
78. Exchange-Rates.org (2024) Historial 2023 del tipo de cambio del peso chileno (CLP) al euro (EUR). <https://www.exchange-rates.org/es/historial/clp-eur-2023>. Accessed 2 Oct 2024

Authors and Affiliations

Gemma Morell-Delgado¹  · **Laura Talens Peiró**^{1,2}  · **Susana Toboso-Chavero**^{1,3,4} 

✉ Gemma Morell-Delgado
gemma.morell@uab.cat

- ¹ Sostenipra Research Group (2021SGR00734), Institut de Ciència i Tecnologia Ambientals (ICTA-UAB, 'Maria de Maeztu' Unit of Excellence CEX2019-000940-M), Universitat Autònoma de Barcelona, 08193 Cerdanyola del Vallès, Barcelona, Spain
- ² Department of Chemical, Biological, and Environmental Engineering, School of Engineering, Universitat Autònoma de Barcelona, 08193 Cerdanyola del Vallès, Barcelona, Spain
- ³ Rotterdam School of Management, Erasmus University Rotterdam, Rotterdam, The Netherlands
- ⁴ Integral Design and Management, Department of Materials, Mechanics, Management & Design, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands