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Assessment study

Used textiles at Kantamanto market

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List of Abbreviations

AMA	Accra Metropolitan Assembly
B2B	Business to business
B2C	Business to Consumer
DTRT	Do the right thing
EEA	European Environment Agency
EuRIC	European Recycling Industries' Confederation
HS	Harmonized Commodity Description and Coding System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GUCDA	Ghana Used Clothing Dealers Association
IRECOP	Integrated Recycling and Compost Plant Limited
KUCSA	Kantamanto Used Clothing Sellers Association
MMDA	Metropolitan, Municipal, and District Assembly
NGO	Non-governmental organisation
NIR	Near Infrared Spectroscopy
OEC	Observatory of Economic Complexity
PET	Polyethylene terephthalate
PCT	Post-Consumer Textile
RDF	Refuse-derived fuels
SHC	Second-hand clothing
SSC	Separate source collection
WCO	World Customs Organization

Exchange rates (Jan 1, 2024):

1 GHS = 0,075 €

1 € = 13,33 GHS

1 € = 1,10 US $

Glossar (Definitions)

Post-consumer textiles (PCT): Textiles that have been discharged after consumption. Commonly also known as “old textiles” or “used clothes”.

Rewearable: Garments that can be reused in their original form for their original purpose. This category is also known as "**second-hand clothing**" (SHC). Collecting and further wearing rewearables can be considered as **reuse.**

Non-rewearable: Garments that cannot be reused in their original form.

Downcycling of textiles: processing of garment textile products for reduced value application (compared to clothing) such as fibres for insulation, mattress filling, rags or wiping tools.

Recycling of textiles: processing of used textile products into secondary raw materials for similar applications to their original use or with comparable value. Typical applications are fibre-to-fibre recycling, also applicable for energetic use and chemical recycling (production of polymers from synthetic textiles).

Textile-to-textile recycling: textile recycling processes where the output is used again in this specific sector in similar applications for which it was first developed.

Upcycling of textiles: processing of used textile products into goods of higher value. For example: manufacturing of flip-flop sandals from old tyres.

Textile waste: waste materials (for final disposal) derived from post-consumer textiles, which are not subject to any recycling or reuse measures.

Disruptor: an element or hard point present on a textile product (e.g. fastener, button, zipper, fabric patch etc.) that may be a disruptor to the recycling process and will need to be removed before the product is suitable as feedstock for recycling.

Cuttings: textile waste, which origins from manufacturing of textiles (new and used ones).

1 Introduction

1.1 Overview

This document represents the main deliverable of the work package 1 of the consultancy on the *Elaboration of a study and development of business cases in the framework of a pilot project for recycling of textile waste in Ghana* contracted by GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit). The purpose of this document is to provide insights and an enhanced understanding regarding the handling of used textiles in the vicinity of the Kantamanto market in Accra, Ghana. Improvements in knowledge, derived from this study of multiple parameters, will aid the development and piloting of recycling. This recycling will improve the circular economy, reduce waste, as well as reduce emissions and conserve resources.

1.2 Background

Garments are an essential component of our livelihoods and, thus, of human consumption. Consequently, the textile and apparel industry is one of the most important and profitable manufacturing sectors. The per capita purchase of garments in Germany ranges between 10-15 kg per year, and this adds up to sales amounts of more than 1 million tons. Recent changes in consumption patterns have resulted in a large increase in clothing sales pushed by “fast” and “ultra-fast fashion” trends; urging consumers to buy more clothes and wear it less often. When a piece of garment reaches its end of use point it becomes legally textile waste. However, a particular portion is collected separately through various systems such as used clothes container and drop off places operated by welfare institutions or textile companies. Some data is available for the separately collected textiles: for example, Umweltbundesamt (2019) reports for 2013 that around 900,000 ton was produced in one year. In contrast, the portion of old textiles collected with the municipal solid waste is not well known. Minimums of approximately 20-30% are directly discharged into the waste bin, but there may be significantly more.

According to Reinckenhoff & Ahlmann (2023) around 55% of the separately collected old textiles are rewearable, while the remaining is subject to material or energetic processing. The supply in rewearable old textiles far exceeds the demand of the national second-hand market. Thus, a significant portion of those clothes is exported, predominantly to less economically developed countries in the global South. On one hand, the imported used textiles have created a significant economic benefit in the destination countries, and on the other hand they cause some problems and challenges.

In response to the observed challenges the German (and the European) government has launched several initiatives to tackle problems coming along with trading in old textiles. The GIZ plays a vital role in identifying and developing adequate mitigation actions. This study is one element of a broader campaign which has several goals: (i) reducing environmental problems particularly around the Kantamanto market in Accra, one of the outstanding destinations of textile exports; (ii) to establish valuable circular economy measures; and (iii) to foster North-South collaborations. The overall goal is to contribute to more sustainable economic activity in textiles via a feedback loop to the textile companies.

2 Scope of work

2.1 Relevant previous reports

n/a:

2.2 Objectives and Tasks

The objective of this project's work package 1 is to provide a robust analysis of the existing situation around the Kantamanto market; aiming to develop business cases for recycling or circular economy measures that target fractions of the old textiles, which cannot be sold as rewearables or which cannot efficiently be processed. In order to identify and develop attractive business cases a clear understanding of trading schemes, the stakeholder landscape, waste amounts and composition, available and adequate technologies, economic and financial parameter of options etc. is necessary.

In the following chapters the study addresses those factors:

- Chapter 3: The used textile situation in Ghana
- Chapter 4: The textile waste
- Chapter 5: The Consultants' on-site investigation on waste amounts and composition
- Chapter 6: Existing processing of materials
- Chapter 7: Technology options
- Chapter 8: Framework for potential North-South collaboration

2.3 Activities performed

The consultancy was contracted on June 20, 2023 and started after the mobilization of experts. The internal kick off was virtually conducted on July 13, 2023. The following activities were performed:

- Familiarization of the experts, literature study, stakeholder talks
- Field mission I (Engelhardt): Sep 18-30, 2023
- Field mission II (Engelhardt, Haden): Nov 20 – Dec 22, 2023
- Field mission III (Engelhardt): Mar 16 – 28, 2024
- Remotely organized field works Dec 2023 – Jan 2024 (textile purchasing campaign, sorting activities)
- Preparation of technology trials (biochar, RDF)
- Site visits at processing plants in Germany and neighbouring countries

3 Used textile market situation in Ghana

3.1 Used clothes handling in countries of origin

Used clothing enters the Ghanian market from different directions; and two of them are the EU and North America. In those areas used clothes are dealt with differently: in the US for instance, clothes are mostly landfilled, combusted or recycled (EPA, 2018). From those clothes that are declared as recycled, around half of them are "[…] simply shipped abroad to other countries […]" (Lundberg & Devoy, 2022).

The EU reports (only) 22 % of post-consumer textile waste being collected for re-use or recycling (European Comission, 2023). In response to the low rate the EU is promoting a new strategy for sustainable and circular textiles, which includes the mandatory establishment of separate textile waste collection by January 1, 2025 (eur-lex.europa.eu, 2024).

Zooming in on Germany, it is notably that the collection is primarily reliant on independent containers. However, there is also the possibility to individually resell/swap clothes online or offline, and giving the clothes to shops for reselling (Schirmer, 2024). The cost of the containers is covered by the reselling of clothes (Reinkenhoff & Ahlmann, 2023). Through this system Germany reaches quite a high recovery rate of 70 % of used textiles (Reinkenhoff & Ahlmann, 2023). Figure 1 (Umweltbundesamt (German Environmental Agency), 2019) illustrates the high portion of separate collection (890.000 t, equal to 82%) compared to the amounts found in the regular waste collection (194.000 t, equal to 18%).

The management of used clothes involves a diverse process implemented by multiple stakeholders, including non-profit organisations, municipal waste disposal entities, and private sector companies. There is an increased municipal engagement in the collection of used textiles due to the expected economic benefits and the possibility to reach environmental and social targets (Watson, Aare, Trzepacz, & Dahl, 2018).

In the one-year-sample gathered for the Sorting for Circularity Europe report encompassing 6 countries (Belgium, Germany, The Netherlands, Poland, Spain and the UK), 81 % of the textiles collected by textile collectors consisted of clothing and household textiles (van Duijn, et al., 2022). From this 81 % (1.713.960 t), 55 % were indicated as "rewearables" (49 % as "rewearables", 6 % as "rewearables" with low value) and 26 % was considered "non-rewearable" (van Duijn, et al., 2022).

Based on numbers presented by the Umweltbundesamt (German Environmental Agency, 2019) a detailed Sankey diagram on different pathways of used clothes covering the year of 2013 has been compiled (Figure 1). It confirms that the majority of the used clothes, collected through the separate collection system, goes towards the second-hand market as "rewearables" (around 54 %), a smaller amount goes as "non-rewearables" (around 38 %) towards a recycling process into wipers or insulation material.

More recent data in a similar comprehensive break down is not available. The latest changes can be tracked down looking into (BVSE (Bundesverband Sekundärrohstoffe und Entsorgung), 2020), the so called "Alttextilstudie", a repeatedly validated data base. Between 2015 and 2018 (latest study) the total amount of used textiles increased from 1,18 million t to 1,27 million t.

In parallel the ratio of 2nd hand clothes increased from 54 % to 62 % (amounts: 637.000 t to 787.000 t compared to the above mentioned 484.000 t in 2013). There are still significant uncertainties in the numbers, in particular estimations for the amounts of textiles in the municipal waste (3 kg/capita/year). Anyhow, a clear trend can be seen, that the textile consumption is increasing while the average duration of usage decreases. Consequently, a general European wide increase of collected used textiles is expected in 2025, additionally driven by the then obligatory establishment of a separate textile collection (eur-lex.europa.eu, 2024) (Mortensen, 2023).

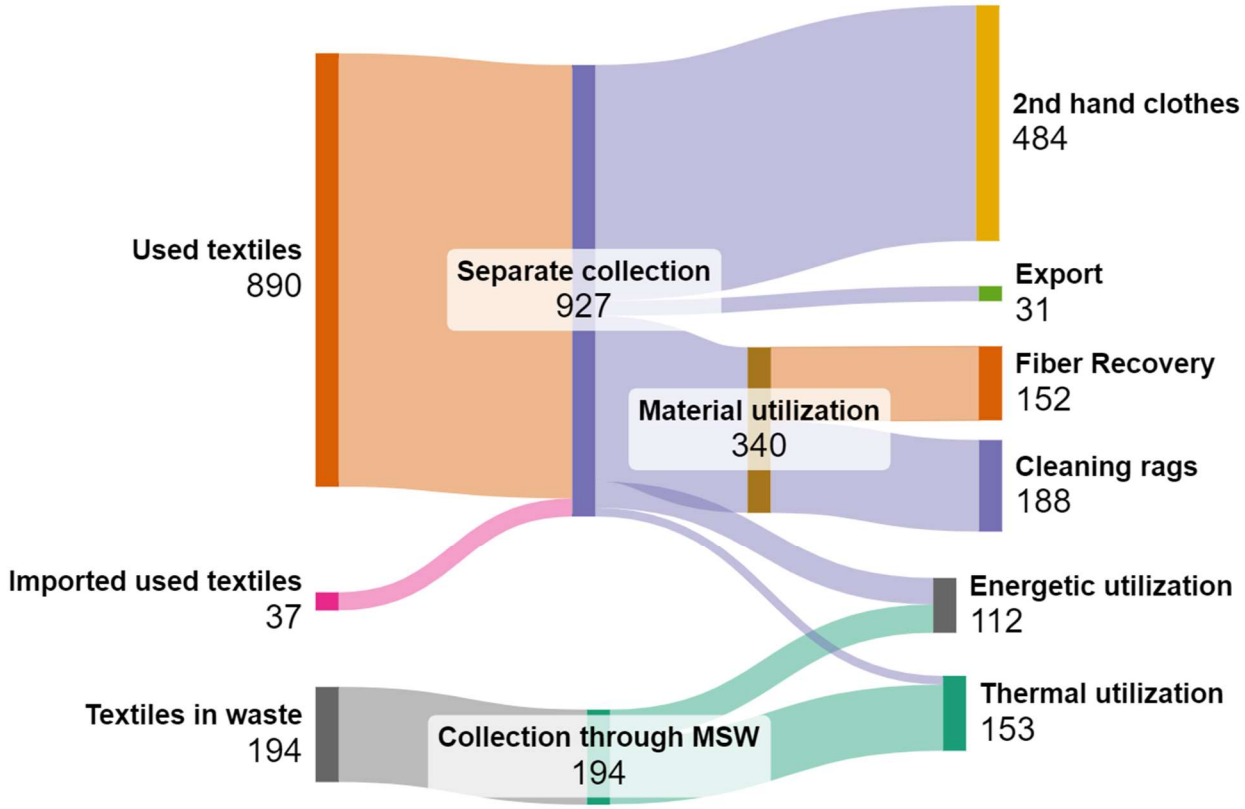


Figure 1 Sankey diagram covering the streams of textiles in 2013 (own figure according to Umweltbundesamt, 2019)

The material flux diagram further illustrates the final utilization of the used textiles and the textile waste in Germany beyond the significant fraction of rewaerables (2nd hand clothes). Back in 2013 only mechanical recycling (fibers or rags) and thermical recycling took place; meaning that there was no thermomechanical or thermochemical recycling (such as fiber-to-fiber or yarn-to-yarn). Only small changes have occured between 2015 to 2018.

The sorting process in Europe is mainly taking place in the Netherlands and Poland, though sorting facilities located in lower labour cost areas have a strategic advantage, as this process is a labour intensive field. 200-300 categories are identified for this process, covering goods from almost new to waste (Reinkenhoff & Ahlmann, 2023).

When the used textiles are categorised as “non-rewearable” their likely-new purpose is the waste-to-energy pathway, wipers production (if the material is rich in cotton), etc. Sometimes material is also sorted into specific categories based on the individual needs of a business partner. Intricate and well-established relationships between business partners are an essential aspect in the sector (Reinkenhoff & Ahlmann, 2023) (Interview1, 2024) (Interview2, 2024).

Sorted materials are exported to business partners worldwide, while also unsorted or only partially sorted material is increasingly exported from Europe (Reinkenhoff & Ahlmann, 2023).

3.2 Imports of used textiles

3.2.1 World-wide trading of SHC

Available trade data about second-hand clothing (SHC) imports of Ghana is either limited or contradicting. This issue has been addressed in different previous studies. One reason for the limited data is the complex structure of this sector with its multiple distribution ways but also different reporting practices by individual countries for imports and exports. More accurate and detailed data will eventually only be available once traceability - in this case for second-hand clothing - on a global scale has been improved.

Regarding the global trade with second-hand clothes, it should be emphasized that a country where used textiles are collected does not necessarily have to be the same as the country where the textiles are recycled or exported as second-hand goods (Reinkenhoff & Ahlmann, 2023). In fact, the country of origin changes during sorting, fractioning and other pre-processing steps. For example, significant amounts of separately collected post-consumer textiles (PCT) from Germany are exported twice, first to Belgium and the Netherlands for sorting, and afterwards for trading overseas. And even the overseas shipping faces intermediate transfers at recycling hubs in Turkey, Tunisia, Dubai or India. Therefore, it is impossible right now to statistically track down and precisely quantify the used textile stream from Germany to Ghana.

Used textiles exported by a country are usually divided into two main product codes under the Harmonized Commodity Description and Coding System (HS) developed by the World Customs Organization (WCO):

- HS 6309 for “worn textiles and clothing”
- HS 6310 for “sorted and unsorted used rags and textiles scraps”

According to the European Environment Agency (EEA), HS 6309 is generally assigned to textiles fit for reuse (SHC or rewearables). HS 6310 should be used for textiles unfit for reuse, destined to be processed into other products, such as industrial rags, or otherwise recycled (EEA, 2023). Textiles under code HS 6309 are regularly considered goods, while textiles under code HS 6310 might be considered waste (Watson, et al., 2016). Nevertheless, either fraction may contain small portions of textile waste since sorting is done manually (even in well-equipped and established sorting companies) and may be subject to mistakes. On a global scale, however, there is much uncertainty about the quality and nature of used textiles categorised as HS 6309. A major part of textiles is exported unsorted as so-called “originals” and are likely to contain both items, fit and unfit for reuse (Watson, et al., 2016). Importantly, traders prefer labelling as HS 6309 to avoid extended import regulations.

Usually, the import and export of category HS 6310 is taking place between countries with an established recycling infrastructure and / or a market for these items. In the past 5 years Bangladesh and the USA were the top export nations of HS 6310 (by value), followed by different countries changing their ranks, including Pakistan, Netherlands and Poland. On the receiving side India and the USA are dominating the list of importers. In order to contextualize the dimensions; the import of HS 6310 in 2022 by Ghana was 1.300 t compared to a 590.000 t by India (www.trademap.org, 2024).

As this study focuses on second-hand clothes that are imported by Ghana, only the category HS 6309 is considered in the further context of this study (as mentioned above, HS 6310 imports to Ghana are very small as it is). Analysing the main import and export countries of second-hand clothes has been conducted to evaluate the economic relevance and to understand material flows and logistics - enabling plausibility checks for field data.

Table 1 and 2 show the ranking of the 5 main export nations of SHC by weight and by value for the years 2019-2022 (www.trademap.org, 2024). For more details about exports from the EU, EEA (2023) gives a comprehensive insight.

Table 1 Global Export nations of SHC by value

Worldwide Exporter by value in 1000 USD

Rank	2019		2020		2021		2022	
1	USA	$681.494	USA	$663.348	USA	$830.964	USA	$953.596
2	UK	$522.646	China	$382.134	China	$753.481	China	$868.200
3	Germany	$381.267	UK	$320.392	UK	$397.946	UK	$445.419
4	Korea	$337.044	Germany	$297.699	Germany	$352.677	Korea	$374.089
5	China	$334.074	Korea	$288.606	Korea	$346.942	Germany	$343.440

Table 2 Global Export nations of SHC by weight

Worldwide Exporter by weight in tons

Rank	2019		2020		2021		2022	
1	USA	765.872	USA	621.784	USA	724.613	USA	720.125
2	Germany	532.639	Germany	492.652	Germany	518.126	China	603.666
3	China	338.214	Korea	298.155	China	399.378	Germany	470.898
4	Korea	327.448	China	290.700	UK	357.741	UK	416.781
5	UAE	274.709	UK	292.646	Korea	335.804	Korea	301.376

The statistics allows some interesting conclusions: for instance, when calculating the per capita export of SHC in kg/year (USA: 2,2, China 0,5, Germany 5,5) or the average value of exports in $/kg (USA: 1,30, China 1,45, Germany 0,75). The data suggests that Germany exports the highest amounts per capita but sells at lowest rates. This confirms the above information on high collection rates as well as the fact that SHC sorting and processing takes place abroad.

Table 3 and Table 4 illustrate the ranking of importing countries by value and by weight (www.trademap.org, 2024). As Table 3 indicates, in recent years Ghana has been amongst the main import countries for second-hand clothes globally in terms of value. After peaking in 2021, yields plunged in 2022 and positioned Ghana as rank 5 just behind Kenya. This observation, however, is valid only for traded value. In Table 4, which shows the ranking of countries based on the imported weight of SHC, Ghana is not listed in the top 5. That suggests that the imports may not be characterized by value (or quality?), but by mass (weight). Comparing the average rates in 2022 Pakistan yields 0,52 $/kg, while Ghana arrives at 1,34 $/kg – almost three times the amount.

Table 3 Global import nations of SHC ranked by value

Worldwide Importer by value in 1000 USD

Rank	2019		2020		2021		2022	
1	Pakistan	$230.780	Pakistan	$204.630	Pakistan	$402.700	Pakistan	$422.790
2	Ukraine	$183.940	**Ghana**	$183.150	**Ghana**	$214.790	Guatemala	$209.100
3	**Ghana**	$175.110	Ukraine	$158.550	Ukraine	$176.200	UAE	$176.410
4	Kenya	$173.990	Netherlands	$133.420	Kenya	$172.680	Kenya	$169.440
5	Netherlands	$130.270	Russia	$120.600	Netherlands	$162.320	**Ghana**	$164.820

Table 4 Global import nations of SHC ranked by weight

Worldwide Importer by weight in tons

Rank	2019		2020		2021		2022	
1	Pakistan	558.470	Pakistan	483.180	Pakistan	933.990	Pakistan	806.650
2	India	241.970	UAE	185.480	UAE	243.180	UAE	359.010
3	Malaysia	211.610	India	184.600	Malaysia	198.410	Angola	208.360
4	UAE	210.510	Malaysia	164.160	Kenya	183.500	Malaysia	193.130
5	Kenya	184.380	Tunisia	142.020	India	174.540	India	186.540
10	**9 Ghana**	131.690	no data		**9 Ghana**	148.580	**11 Ghana**	122.930

3.2.2 Imports of SHC to Ghana

Zooming deeper into Ghana, according to the Observatory of Economic Complexity (OEC) the share of used clothes from the overall import value of 19,7 billion $ in 2021, made up to a little more than 1 % (Figure 2).

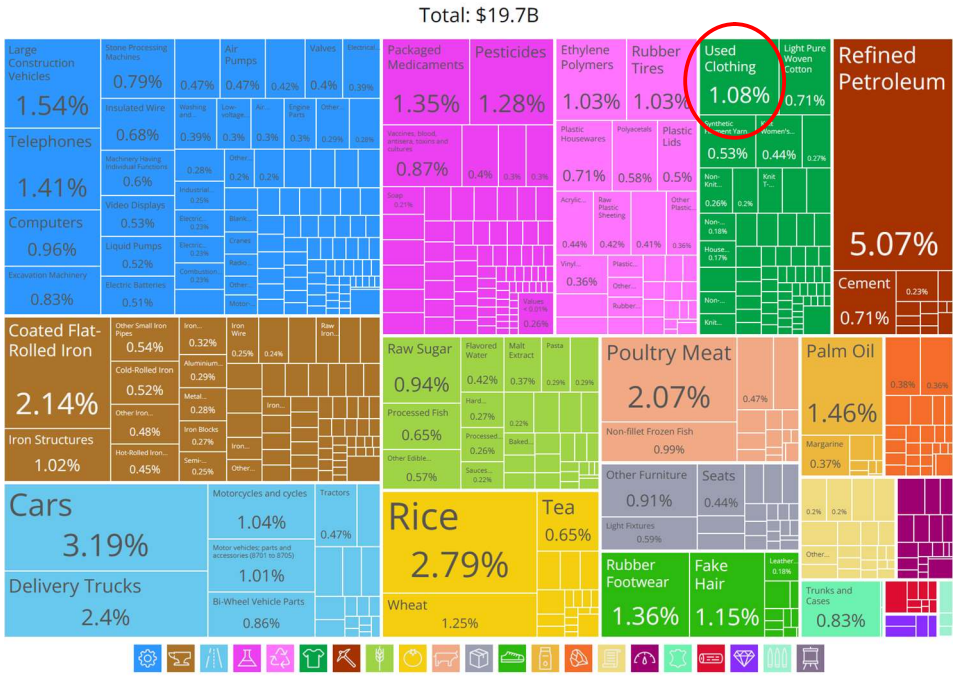


Figure 2 Imports of Ghana in 2021 (OEC, 2021)

The country of origin of imported SHC can also be identified by customs statistics. However, the country of origin is not necessarily the same country, where the SHC have been collected from the consumers. Figure 3 displays the quantity of imported SHC to Ghana (HS 6309) over the period of ten years (2012-2022). The trend in SHC has been considerably constant for most of the ten main exporting countries, except from UK and China, the two leading exporters (combined 63 % of imports in 2022).

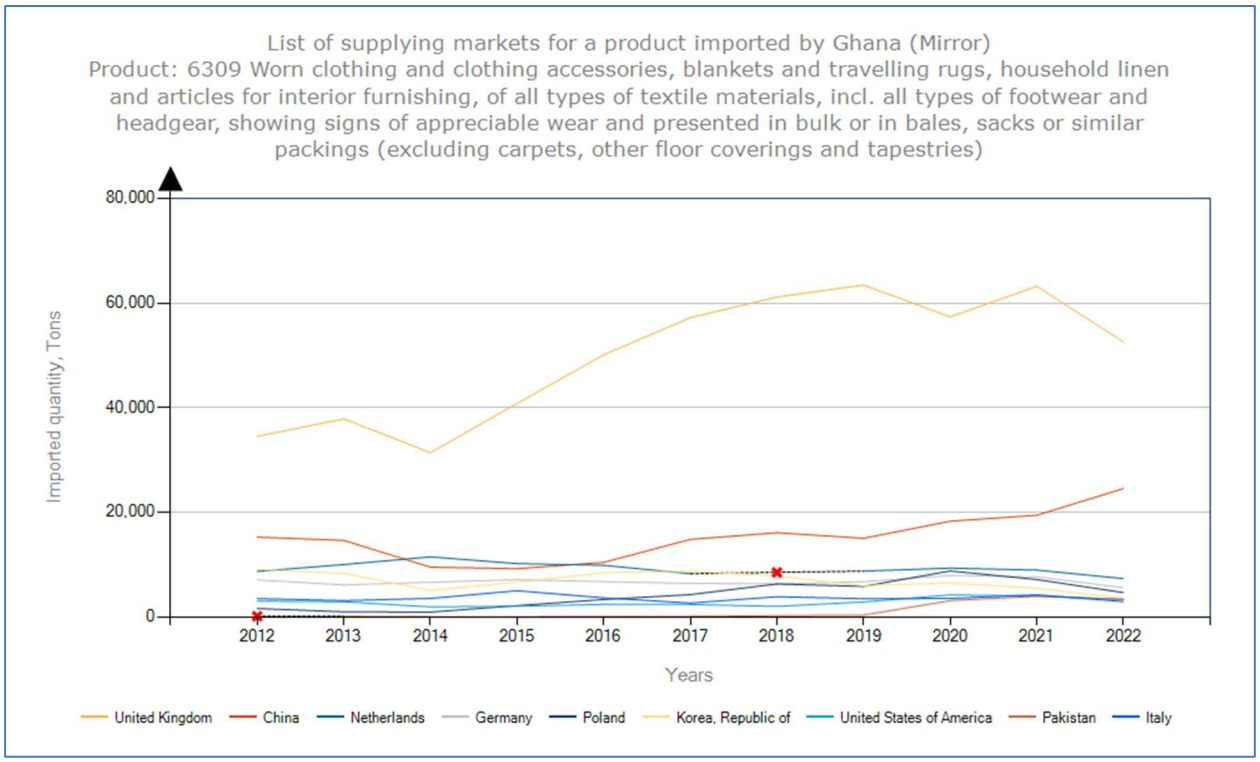


Figure 3 Development of SHC imports 2012-2022 (by quantity) from 10 main supply countries.

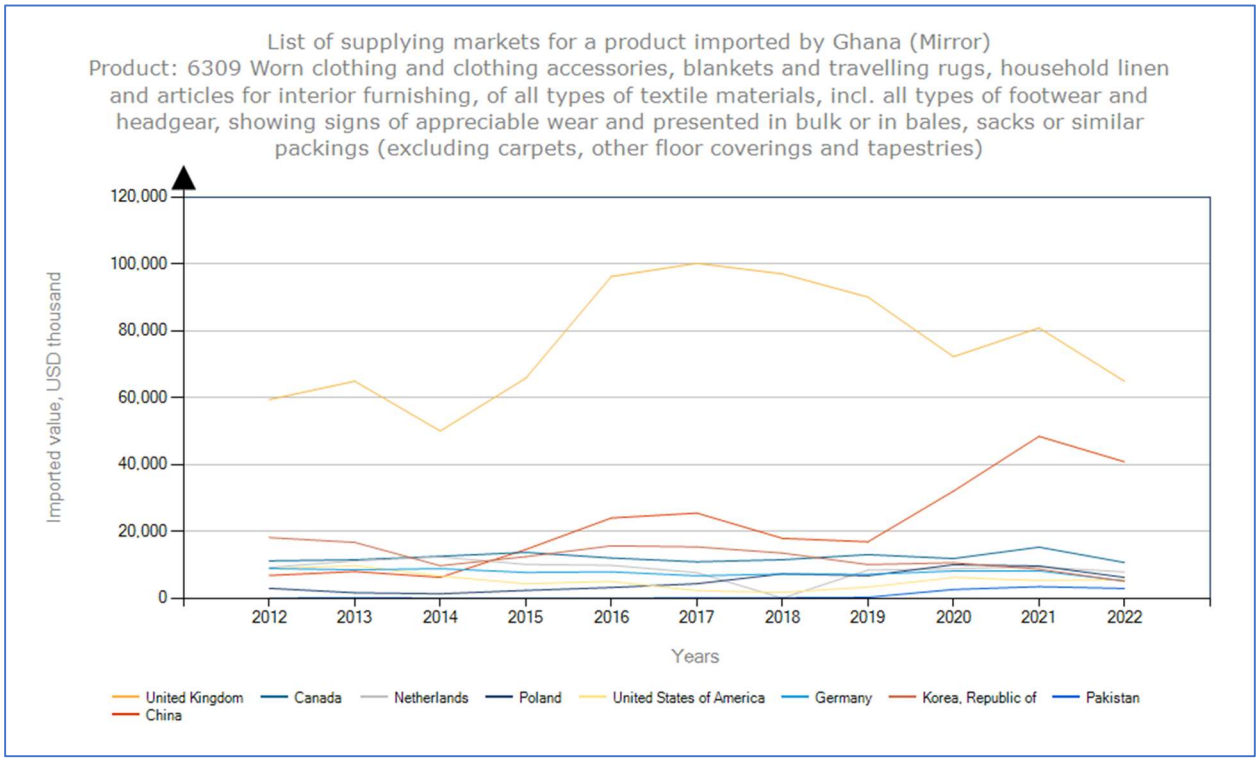


Figure 4 Development of SHC imports 2012-2022 (by value) from 10 main supply countries (www.trademap.org, 2024)

Apart from a decrease in value of imports in 2022 from all countries, there is a strong tendency of decreasing imports from the UK since 2018, whereas imports from China were increasing after 2019. Another observation that can be made is that the weight of imports from China in 2022 increased but the value of imports for the same year decreased. The consultants cannot be certain why this occurred but various interviewees mentioned that an increasing amount of items exported from China to Ghana are actually factory rejects from the fast fashion industry. In any case, the statistics prove that (direct) imports of SHC from Germany are rather marginal.

The development of the total imports of SHC (2018-2022) from all countries over time are illustrated by value in thousand US $ in Table 5 and by weight in tons in Table 6. The overall numbers show that after an increase reaching its peak in 2021, numbers dropped in 2022 to the level of 2018 (www.trademap.org, 2024).

Table 5 SHC imports to Ghana (2018 – 2022) in thousand US $

Imported value in 2018	Imported value in 2019	Imported value in 2020	Imported value in 2021	Imported value in 2022▼
176,337	175,113	183,146	214,785	164,821

Table 6 SHC imports to Ghana (2018 - 2022) by weight in tons

2018	2019	2020	2021	2022
Imported quantity, Tons	Imported quantity, Tons	Imported quantity, Tons	Imported quantity, Tons	Imported quantity, Tons▼
122,828	131,525		148,582	122,934

3.2.3 Trading system overview in Ghana / Kantamanto market

Ghana is the main distribution hub for SHC in West Africa and the Kantamanto market is one of the biggest second-hand markets worldwide (Ahiable & Triki, 2021). The entire trading system with second-hand textiles in Ghana is hierarchically structured. At the same time, it is characterized by its complexity as various actors are in diverse relationships within an informal sector. The relationship between the importers in Ghana and the exporters around the globe is often well-established and guarded. Especially important is the relationship for importers in order to source ever more SHC to meet the demand of their customers (The OR Foundation, 2022).

Second-hand clothing arrives in Ghana by ship at the harbour of Tema (40 km east of Accra) or in Takoradi (140 km east of Ivory Coast border), packed in bales and stacked in 40 foot containers that were chartered by importers in Ghana or neighbouring countries. Some smaller amounts are arriving via land borders (as mentioned in interviews) as a potential pathway for illegal imports to Ghana (e.g. banned second-hand underwear). Loaded onto trucks, an estimated 70 % of all containers that arrive at Tema are transported early Thursday mornings to Kantamanto market, located in the western part of Accra city (Ahiable & Triki, 2021). Accurate numbers are not available, since the trading is very dynamic and depends on recent orders placed by customers. Thursday is the main day for importers receiving containers; but interviewees also mentioned that on Mondays and Wednesdays containers arrive at Kantamanto. The remaining 30 % of containers is transported directly to different locations. These locations include other parts of Accra or within Ghana, such as Tamale or Kumasi. Sometimes imports go directly to neighbouring countries such as Burkina Faso or Niger. Once a container with SHC has left the port, tracking the route for every container and bale or even single items of SHC is impossible.

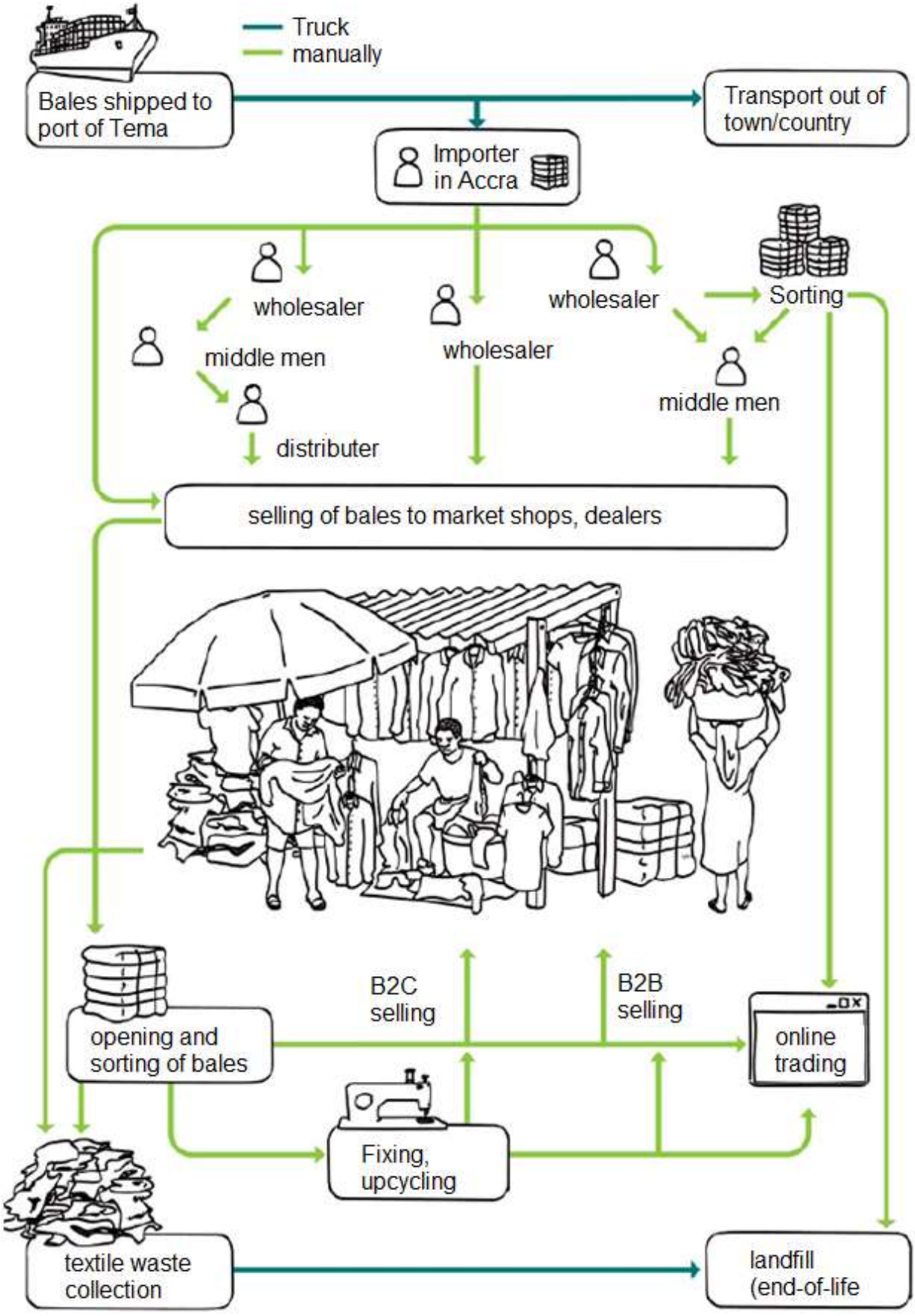


Figure 5 Distribution pathways of secondhand clothes at Kantamanto market (Reinkenhoff & Ahlmann, 2023)

Depending on the distribution pathway of the container, different ways to further handle the bales are possible as illustrated in Figure 5 or for example:

1. Containers get unloaded at a warehouse of importers or wholesalers based in Tema. Either the bales are just stored upon transporting them further to Kantamanto market or the bales are opened at the warehouse in front of traders who select the pieces they want. These traders then pack them in bags and transport them to their stalls at the market.
2. The container is transported to the warehouse of an importer based in the north of Accra. The importer has his own thrift store, where the SHC is sorted into different categories and each item is placed for sale to customers. The items that are not wearable [because they are stained or sizes are too small to fit the average customer (often the case for Chinese wear)] are stored in a corner of the shop as waste. This waste sometimes accumulates over several weeks before some buyer picks it up for little money (400 GHS / 30 € per bag of 70 – 80 kg). The buyer takes these garments to Kantamanto market, in order to sell it there or to recycle it to cleaning rags.

Figure 6 Pile of considered SHC waste for thrift shop retailer

3. The container goes straight to Kantamanto market, usually early Thursday morning, where all bales are initially unloaded by hand and taken to the warehouses of importers or wholesalers. Additionally, some bales are loaded onto smaller transporters for further distribution in Accra or big trucks that get stacked up with bales for export to Niger or Burkina Faso, while other bales go directly into the hands of individual traders for immediate opening and resale.

Upon arrival in a warehouse, the process is usually the same. Wholesalers have ordered bales from importers and sell their goods to intermediate and sub-traders. At each point of resale, the quantity of purchased bales decreases, and the price per bale increases. Usually, the transport of the bales is carried out with the help of so called “Kayayeis” (females working as head porters) or male carriers, who are typically paid based on the distance travelled. The traditional market days are Wednesdays and Saturdays, which is when retailers open their bales as more potential customers are around the market. After opening, the traders undergo another round of sorting based on their standards. The goods are evaluated and divided into categories, such as directly sellable, upcyclable/repairable, or unsellable items. More details can be found at (The OR Foundation, 2022).

Directly sellable goods are prominently displayed for presentation; but interaction with customers often begins during the opening of the bales. Parts are sorted out for interested parties as the bales are being opened. The customers can either represent another level of traders (Retailers) or end consumers. If they are retailers, the goods are offered in their shop at the Kantamanto Market, in their online shop, or as street vendors to end consumers. Through these possible channels, the imported second-hand textiles reach the shops in the market, other neighbourhoods, or outside Accra.

The described trading hierarchy can have more or fewer levels of sub-traders. Additionally, in the Kantamanto market there are processes for customer complaints if they are dissatisfied with the quality after the bale is opened. The grievance is addressed to the respective sub-trader, and a new price is negotiated.

Overall, the trade is characterized by a high level of organization involving various actors, allowing for the nationwide distribution and transportation of second-hand textiles (Reinkenhoff & Ahlmann, 2023)

Some interviewed importers also mentioned that they conduct their own sorting and repacking of particular bales upon arrival. These B2B (business to business) bales are reserved, especially for long-time customers outside Accra, who are willing to pay more for the sorted and, therefore, higher-quality bales. The limited supplies in northern regions and the long transport distances also contribute to the acceptance of higher prices. Additionally, the difficulty of filing a complaint increases with greater distances between the seller and the buyer. Moreover, different importers emphasized that sorting in their own country would enable sorting based on local demand (Reinkenhoff & Ahlmann, 2023).

3.3 Material flow

As mentioned above, exact data for the material flow rates such as the portion of imported SHC, which goes to the Kantamanto market, is not available. The consultant tried to reveal and understand the mass flow from the import all the way to the end of the value chain. The consultant uses literature and data research, local on-site observations and interviews with key stakeholders. The main target was the amount of low-value SHC, which may become waste (or which are already waste). There are three major spots where the ratios of divergent material streams are not exactly known:

- The ports: number of containers going to the Kantamanto market
- The Kantamanto market (wholesaler): percentage of SHC traded on-site
- The Kantamanto market (retailers): sales percentage of rewearables (1^{st}/2^{nd} quality)

Figure 7 summarizes and illustrates the result of the consultants' investigation. The material flow uses the unit of 40" container as a proxy variable for tonnage/week, since the local stakeholders are more familiar with that unit. The consultants concluded that most likely 300 t/week (10 containers) of second-hand clothes are traded in the market, of which about 120 t/week (4 containers) are low value textiles or textile waste. The following section describes how the material flow assessment has been conducted.

- Regarding the latest import data available from ITC trade map, as mentioned in chapter 3.3.2.2, Ghana imported 123.000 t of second-hand clothes in 2022. This equals 2.365 t or **79 containers** per week assuming a maximum payload of 30 tons per container. Most of the containers arrive at the harbour of Tema. However, some also arrive at the port of Takoradi. There is no data available on the distribution of SHC imports between the ports of Tema and Takoradi.

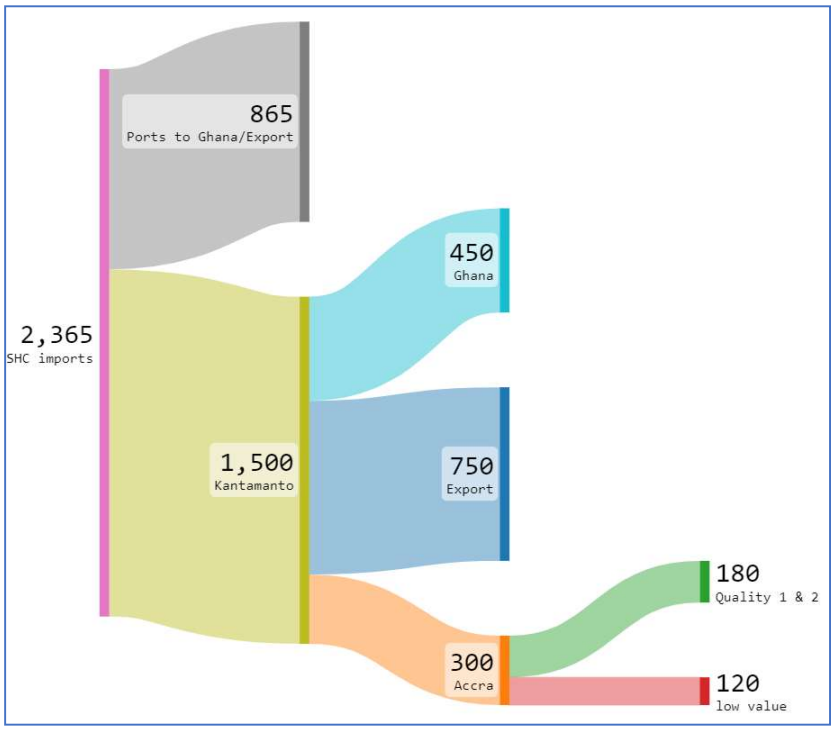


Figure 7: Material flow of imported SHC at Kantamanto market in 2022

- Not all containers, which arrive in the port of Tema, are transported to Kantamanto market; some are sent directly to other parts of Accra, Kumasi, or Takoradi. The Ghana Used Clothing Dealers Association (GUCDA) confirms that on average **50 containers** per week arrived on Kantamanto market (in 2022), which equals about 1.500 t per week. Hence from the total of 79 container (2.365 t) arriving to Ghana, 29 containers (865 t) take one of the other mentioned pathways.

- Of all 50 containers (1.500 t) that arrive at Kantamanto, only a minority of bales get opened at the market according to GUCDA:

    - 50 % or **25 containers** are determined for direct export to neighbouring countries. Once the container arrives at Kantamanto, the bales get unloaded and loaded to trailer trucks for further transport (Figure 8).

    - 30 % or **15 containers** (750 t) are determined for further transport to other markets of the country, e.g. to Kumasi, which is the distribution hub for the north of Ghana.

    - 20 % or **10 containers** with approx. 5.450 - 6.600 bales (at a bale unit weight of 45 – 55 kg each) of SHC are determined to be opened and its garments to be sold at Kantamanto market. In terms of weight, this equals 300 t per week. As mentioned at (The OR Foundation, 2022) there are around 5.000 retailers at the market of which most of them open one bale on Wednesday or Saturday and sometimes on both days. This information is quite congruent and considering the 5.450 – 6.600 bales to be opened at Kantamanto would allow between 9 % – 32 % of the retailers to open 2 bales per week.

- Little is known about the portion of low value SHC/textile waste versus the high value SHC (so called 1st and 2nd quality). In most literature, a quota of 60 % for high value SHC is presented, which was first published by The OR Foundation (2022) and has been replicated in many other reports because no alternative data is available.

Although the estimated 300 t/week match other information (such as the number of retailers and opened bales) it should be noted that the numbers could be significantly different, probably by a factor of 2.

Figure 8: Trucks from Nigeria getting loaded with SHC bales for export at Kantamanto

3.4 Material composition of imports

Sorting companies in Europe and worldwide sort their input material usually based on categories of items, such as light jacket, shirt, cotton lady dress etc., but not regarding their material composition. It has also been observed that a bale labelled with “cotton ladies dresses” does not necessarily contain only cotton dresses. Instead maybe 20-30% of the items in the bale are partially or fully synthetic. It is, therefore, not possible to exactly evaluate the material composition of overall SHC imports or for rewearables. As it was reported from different stakeholders, the whole business is very dynamic which is not only reflected in the amounts of SHC imported but also in the composition. On the customer side, preferences for a specific material vary broadly. For instance, in different interviews, the preference for synthetic clothes was mentioned, as their colours are usually brighter and less faded as the cotton. Others mentioned their adversity for synthetics due to the climate in Accra, where natural and breathable fibres are preferred.

Of course, materials and fabrics are a characteristic selling point for SHC as rewearables, since it is a purchase decision criterion for customers, and it may also affect the price of a garment. However, in the context of this study information on material composition is more important for the non-rewearable fraction, because it significantly affects the options for processing. However, the data availability for this composition is scarce. Consequently, comprehensive field investigations have been carried out to determine the material composition of the low-value textiles collected at the market. The results are presented in chapter 5.3.

3.5 Market players and infrastructure

As the trading procedures are described above, the section below provides more details on the features and set-up of the Kantamanto market.

Market Overview:

- The Kantamanto Market functions as a diverse marketplace attracting both professional traders and private end consumers.
- Most items offered are second-hand goods, primarily textiles, but the market also encompasses various related trades and diverse product offerings; including food, small animals, spices, electronics, and accessories.

Market Organization:

- The market is centrally organized with approximately 5.000 shops, requiring traders to pay stand fees, composed of:
    - electricity (50 – 150 GHS),
    - sanitation (3 GHS per week) and
    - security (20 GHS per month)

  Additionally, most of the vendors pay extra money (5 – 7 GHS) to informal waste transporters to remove bulky waste in front of their stalls such as piled-up clothes that they have no use for. Many of the shop stalls are owned by former traders who used to work at the market but now rent out their stalls. Depending on the size and construction, the rental fee per month ranges from 120 – 300 GHS. The purchase price for a stall can vary from 25.000 – 300.000 GHS.
- The market spans a considerable area, covering 28.300 square meters of selling space and an additional 60.700 square meters for surrounding warehouses, totalling 89.000 square meters.
- The main part of the market is divided into 6 sections. Each section with its traders is represented by an elected chairman from the Kantamanto Used Clothing Sellers Association (KUCSA), not to be confused with the Used Clothing Dealers Association (GUCDA) which represents the interests of most importers at the market.
- The surrounding area features streets lined with warehouses and shops.

Shop Layout and Merchandise Display:

- Shops are aligned along narrow paths, functioning as two to six square meter niches filled with displayed goods.
- Merchandise is typically hung on hangers or wooden rods to attract potential customers and showcase materials quality.
- Sellers, both standing and sitting, operate within and in front of these niches.

Product Specialization:

- While the market lacks strict product divisions, specific areas house larger groups of sellers specializing in particular goods.
- Shops targeting end consumers typically focus on a single product such as shoes, lady dresses, jeans etc., ensuring a consistent offering throughout the year.

Wholesale Sections:

- Distinct sections are reserved for wholesalers, facilitating the sale of larger quantities of textiles to other traders.

Market Dynamics and Culture:

- Despite its potentially disorderly appearance, the market operates as a well-organized and closed system with clear rules, task distributions, and hierarchies.

Sewing and Dyeing Workshops:

- Sewing and dyeing workshops equipped with industrial machines operate within the market, primarily undertaking commissioned work for traders.
- Separate sewing niches between retailer shops cater to end consumers seeking alterations.
- Some sewers are at the same time entrepreneurs that create upcycling products e.g. bags made from old denim jeans.

3.6 Pricing and financial aspects

Regarding the pricing, information is often kept as a secret or random numbers are made up, bigger or smaller depending on the expected interest of the interviewed person, as it accounts for any other business and sector. A common difficulty that was highlighted in the interviews was the consequences of volatile currency exchange rates and the increase of customs duties on imports.

- The exchange rate poses the greatest risk for importers in trade, coupled with rising tariffs (duties, etc.). The tariffs can fluctuate significantly and have nearly doubled in the recent past.

- The import duty and custom fees for a 40-foot container is based on its weight. In January 2024 the fee ranged between 120.000 – 140.000 GHS (9.000 – 10.500 EUR).

- The freight costs depend on the exporter's location. For the transport between Accra and The Netherlands, an estimated 2.800 – 3.200 EUR were mentioned in interviews.

An estimation of the load of the container is even more difficult. On the one hand, this information is well protected by the importers, on the other hand, it varies extremely depending on the item category. The range of cost for a container load mentioned in interviews was between 4.500 – 64.000 EUR.

Considering the average Ghanaian gross national income of 2.380 USD per year (198 USD/month), purchasing a bale for 650 – 4.000 GHS (54 - 330 USD) can be a significant investment for sub-traders. Pricing involves negotiation and haggling with no fixed prices, making it challenging to provide absolute statements about item prices.

There is no reliable data on the actual profit from selling a bale to end consumers in Ghana. Traders mention profits of 100-150 GHS on a challenging day, but the figures vary widely. Some days see higher profits, while on others, they may not cover the bale costs.

Table 7 Prices for garments for different qualities (price per item)

Item	Item per Bale	Quality 1 (GHS)	Quality 2 (GHS)	Quality 3 (GHS)
Lady Dress	220 - 260	40 - 150	20 - 30	10 - 15
Jeans	150 - 175	70 - 250	20 - 40	10 - 15
Business Shirt	220 - 260	40 - 120	20 - 30	5 - 12
Towel Big	90 - 120	60 - 150	30 - 50	15 - 30
Towel Small	180 - 210	20 - 45	15 - 20	10 - 15

N.B. At the market retailers regularly bargain 1 GHS garments (out of Quality 3)

The economic risk increases within the market structure with each level of sub-traders, which is reflected by the quantity of purchased bales per intermediate and sub-trader. Consequently, the lower levels have minimal opportunities to save capital and advance in the structure. Instead, constant reinvestment with a narrow profit margin is required at the lower levels, which may push those sub traders into a vicious debt cycle.

One importer with his own shop outside of Kantamanto market (where second-hand clothes are sold per kilo not per item) mentioned his costs are equal to 1.500 GHS per bale (incl. freight and customs, etc.) Based on the maximum loading weight of a container of 30.000 kg and the weight per bale of 55 kg the following calculations can be made:

Costs:
1 bale of 55kg = 1.500 GHS
1 container max. load 30.000 kg = 545 bales
545 bales x 1.500 GHS = 818.000 GHS

Profit:
Revenue: 30.000 kg x 100 GHS/kg = 3.000.000 GHS
Costs = 818.000 GHS
Profit = 2.182.000 GHS (164.000 EUR)
(this amount translates into a profit of 4.000 GHS / 300 € per bale)

The sales unit rate of 100 GHS/kg was obtained from local market observation

4 Textile waste

4.1 Waste criteria

As elaborated in chapter 3, reliable and accurate data on amounts of imported second-hand clothes and the portion of rewearables is difficult to determine. And much of the data is based on some assumptions and estimations. However, it is generally understood that approximately 120 t SHC/week are difficult or impossible to sell as rewearables. This fraction can be summarized as low value textiles and it is subject to further analysis.

A particular portion of the low value textiles is or will become textile waste. Waste, according to German law, is defined as *any substance or object that the owner discards, intends to discard, or is required to discard*. The German Circular Economy Act (Kreislaufwirtschaftsgesetz) further specifies waste as materials that are no longer needed and are destined for disposal or recycling (umweltbundesamt.de, 2024). Similarly, EU law, particularly the Waste Framework Directive (2008/98/EC), defines waste as *any substance or object that the holder discards, intends or is required to discard*. It includes materials that are abandoned, recycled, or recovered (eur-lex.europa.eu, 2024). Whether or not the separate collection of old textiles is a waste management activity is still under debate in some member states (in Germany it is a specific form of waste collection).

The general definition of waste by the above-mentioned laws is quite clear. However, the criteria for second-hand clothes being waste or not are a controversial and complex topic. The complexity is important when the goods are on the way to re-entering the circular economy. It should be understood that the term “waste” is a legal term and not a technical one. From a technical (or economical) point of view the distinction between second-hand clothes as waste or as a resource is not absolute, but subjective depending on the condition, intended use, and management approaches applied to these garments.

The perspective of different stakeholders and actors can vary depending on cultural, economic, and environmental factors. In this context, SHC can be considered waste when they are discarded, unwanted, or no longer suitable for their original purpose. If they are destined for disposal or end up in landfills without any further use or value, they are generally classified as waste. This can include garments that are torn, stained, or overly worn, and are deemed unsuitable for reuse or resale. It also includes garments which are unsellable because they are outfashioned.

When it comes to SHC in Ghana, particularly in the context of the Kantamanto market, understanding the definition of waste becomes crucial to ensure clarity and prevent misconceptions. Defining what is considered waste within this framework becomes essential when discussing this subject in order to avoid any confusion or misunderstandings. As described in chapter 3 above, once the bales with SHC are opened they quickly get sorted in different qualities. **Quality 1** and **Quality 2** are often sold right on the spot. What is left is often **Quality 3** and considered “waste” if it does not get sold within a week or two. **Quality 4**, known as "under”, consists of garments with slashes, large holes, or noticeable stains - they are essentially considered unsellable and retailers see no value in them.

Quality 3 is the category which is the most controversial fraction regarding its classification of being waste or a resource. So can, for example, a lady jeans immediately become waste for a retailer that is specialized in male jeans if he or she considers the garment as not sellable to their customer base.

Regardless if the garment looks brand new. Though maybe a neighbouring shop a few stalls down the lane is specialized in lady jeans and able to sell it. All depends on the evaluation of its owner, if he or she decides to dispose of it because for them the garment has no value, it becomes waste, as defined in the laws mentioned above. However, not all garments that are disposed of as waste are of no value to everyone. The Kantamanto Market is a prime example for a circular economy, at least downstream. Among the numerous individuals active in this microcosm of Kantamanto Market, there is a considerable number that see a resource in this waste, trying with much creativity and effort to extract this value in order to make a living. It is important, therefore, to differentiate between the waste that nobody is interested in and thus destined to leave the market as such and low value textiles, which are formally waste but can (and will) be recovered within the market because it holds still value for someone else.

It should be noted that the definition "rewearable" is an economic classification. It includes all garments, which can be sold for reuse (rewearing). There are products, which are technically rewearable. However, some rewearables nobody wants to wear, because they are not fashionable (wrong fashion style) or they are not seasonal (winter sweater) and, thus, they are unsellable. As per definition those will fall under not-rewearable. On the other hand, a garment classified as non-re-wearable could stay within the market and regain value through upcycling, like a torn pair of jeans transformed into a denim bag.

Textile waste in context of this study is defined as any garment that is deemed to leave the market in one of the below mentioned waste pastways, because it is considered of no value for nobody. As elaborated in chapter 5.3, this textile waste is composed of the unsellable portion of the (technically rewearable) Quality 3 and non-rewearable Quality 4 garments. **Cuttings** from tailors fall regularly under textile waste.

4.2 Used textiles vs. textile waste (mass flow)

In the sections above the mass flow of the SHC is described in detail including the uncertainties regarding the amounts, which remain in the vicinity of the Kantamanto market. The low value fraction of the SHC, which is traded at Kantamanto market and from which a part will finally become textile waste amounts to 120 t/week (Figure 7).

4.3 Waste handling

In the waste landscape report (The OR Foundation, 2022) six different waste pathways have been identified that describe the optional tracks that SHC waste is leaving the market (Table 8). Table 8 indicates that the majority of textile waste leaves the market by means of official waste transportation (59-75 %). Open burning around Kantamanto and open irregular dumping (each 12-19 %) are the other popular pathways, while the remaining options contain negligible amounts. Waste transportation at Kantamanto is performed by a private company (Zoomlion), which is contracted by the Accra Metropolitan Assembly (AMA), since waste management falls under the responsibility of the Metropolitan, Municipal, and District Assembly (MMDA), according to the National Environmental Sanitation Policy (2010). Zoomlion usually transports one truck per day from Kantamanto market to the Adipa landfill (50 km north of Accra); however, it is unclear what exact amount of textile waste is actually transported (see chapter 5.4).

Table 8 Waste pathways from Kantamanto market (The OR Foundation, 2022)

Pathway	Approx. Range of Daily Garments	Approx. % of Waste Stream	Approx. Range of People Involved
Official Waste Hauling	250,000 - 450,000 Garments	59-75%	Hundreds (including those who collect and bring to road)
Burning Around Kantamanto	40,000-150,000 Garments	12-19%	Hundreds
Open Dumping	40,000-150,000 Garments	12-19%	Hundreds
Burning to Heat Water	500-5,000	<1%	Tens
Scavenged	250-5000	<1%	Hundreds
Industrial Rags	100-500	<1%	Tens

The formal sweeping service inside the market, which is financed through the sanitation fee every retailer is paying to their association (Chapter 4.3), is conducted by 13 mostly female waste sweepers. The cleaning of the narrow market aisles takes place in the late afternoon, typically after the shops close (approximately between 5 pm and 8 pm). The sweepers place the waste at designated corners from where it gets further transported in bags to usual pick-up points for tricycles or official waste collection in the northern market area. This transportation is predominantly carried out by individuals without the aid of machinery, and thus on their shoulders and heads or trolley carts.

Neither AMA nor Zoomlion are operating or collecting from within the market. The waste generated by retailers, such as piles of unsellable textile waste, is typically removed from the market by informal private waste transporters (so called “Bola” guys), with disposal occurring in irregular locations like Odaw River, Old Fadama dumpsite, or other areas with minimal to no associated costs. These waste transporters walk around the market offering their service to collect and dispose the waste from the shops for 5 – 7 GHS, depending on the amount of waste.

Figure 9 Burning of waste (often textiles) next to the Railway station at Kantamanto

A prevalent yet concerning practice is burning the garments that are deemed worthless, around the market. Another form of burning textile waste is taking place when utilizing it as a source of fuel to heat water for showers at Kantamanto market. In this context, the textile waste holds a monetary value, as individuals pay for the hot shower.

In parallel, waste-picking activities take place in the market as well as at the disposal places, where individuals pick valuable items, either for their own need of clothes or with the intent to further sell the clothes.

4.4 Waste disposal

Waste disposal as a component of solid waste management is also under the legal responsibility of AMA. The major disposal site is a controlled landfill located in Adepa about 50 km north of Accra. The operation of the landfill has been outsourced to the private company Zoomlion. Figure 10 displays impressions of the Adipa landfill. The site is the major disposal site for the Accra Metro region with a population of 2,6 million, who generate about 1.500 t of municipal solid waste per day. The one tipper truck of textile waste, which Zoomlion discharges daily at Adipa, represents a rather homeopathic amount of the overall waste. Consequently, no large mono charges of textile waste were found during a site visit.

Figure 10 Adipa landfill

Nevertheless, the surrounding environment and in Accra itself shows significant traces of irregular waste dumping. Figure 11 shows impressions at the beach area not far away from Kantamanto market. Textile waste forms only a small portion of the waste, which is obviously dumped over the cliff. However, a closer inspection confirms that the largest portion is plastic packaging. Textile waste is a rather small portion and often containing cuttings and industrial textiles (fisher nets). Compared to other coastal

places in Sub Sahara Africa, the environmental situation in Accra is rather poor, but not extraordinary, although direct dumping next to the seaside is uncommon in comparable places.

Figure 11 Irregular waste dumping at the beaches (Kokorobite beach at top, Jamestown beach in Accra at bottom)

5 Field investigations

5.1 Rationale

Two field missions over several weeks have been conducted by the consultant between September and December 2023. In interviews with different stakeholders and visits around the Kantamanto vicinity, the actual amount of waste from SHC has been a topic with the most controvery and differing opinions, ranging from no waste at all up to 100 t leaving the market every day. Observations at the market during the first field mission in Sept. 2023 indicated that the truth lies somewhere in between. The official waste collection truck dedicated for daily waste collection from Kantamanto market has been monitored by the field experts for several days. It could not be confirmed that the truck was almost fully loaded with textile waste as stipulated. The truck seemed rather to be loaded with mixed market waste containing several bags of textile waste. The estimated share of textile waste, however, was not more than 30-50 % of the total waste loaded.

In order to develop solutions for this textile waste (and similar waste materials from other sources) it is deemed necessary to get more reliable data about its amount and characteristics. As a starting point the question on what are the actual quantities that need to be dealt with, or from a technology perspective, what is the available feedstock, shall be answered. Thus, the field investigation aimed at determining the actual amount of waste generated of SHC considering the definition presented in chapter 4.1. In any case it should be noted that the data collection still remained on the level of spot sampling.

The objective of targeting the textile waste responds to the fact that this fraction causes (i) emissions to the environment, especially when improperly disposed of, (ii) is polluting beaches and the ocean or (iii) is generating toxic fumes and greenhouse gas emissions if getting burned. No matter how environmentally sound the fraction is disposed of, it represents an open gap in the circular economy and a waste of resources. On the other hand, it is important to avoid harming existing socioeconomic structures and, therefore, to focus (and limit) on the materials which are determined to leave the market while nobody sees any value in it or is able to generate any value from it.

5.2 Incentive-based collection

5.2.1 Concept

In order to determine the quantities of SHC waste leaving the market every day, a pilot collection was set up at the Kantamanto market with the aim to collect all textile waste and other low value textile materials, which are likely to become waste, before it leaves the market. The activity was carried out in collaboration with the local partner NGO (Non-Governmental Organisation) *The Revival*, a community-led sustainable design non-profit organisation with the purpose of educating, creating awareness, art and jobs with upcycled textile waste. An incentive-based purchase program for textile waste was established in December 2023. The program has been effectively communicated throughout The Revival's extensive network, reaching stakeholders at all levels, including the Used Clothing Sellers Association, waste sweepers, and informal waste pickers, prior to launching the incentive-based collection.

The concept centres on providing an incentive payment for each kilogram of textile waste (and low value textiles) delivered to a designated collection point at the market. Individuals bring a bag of textile waste, get their bag weighed on a digital scale and after recording the data getting paid in cash on the spot. If needed some sweepers were also provided with bags on request.

Figure 12: Incentive-based textile waste collection - impressions

Each day all the collected waste was transported to the final collection site at Zoomlion's daughter company IRECOP (Integrated Recycling and Compost Plant Limited), where a storage area and 40 feet container were rented to store all waste at the secured facility upon sorting. In the beginning the hauling was carried out by a tricycle, and later by a 26-t truck with a loading capacity of up to 14 t (Figure 22).

In order to determine an appropriate incentive amount, careful consideration has been given to ensuring that it is high enough to motivate the transportation and delivery of waste to the collection point instead of its intended disposal location. On the other hand, the incentive was supposed to be set at a level low enough to discourage the submission of otherwise sellable items for disposal, which would result in incorrect numbers. The incentive given to deliverers was set to 0,5 GHS (3,7 €-Cent) per kg, which is lower than the lowest observed clothes prices, which is 1 GHS per garment.

Volunteers for The Revival were communicating the concept around the market to ensure everyone that is usually moving textile waste from the market either to the official collection truck from Zoomlion, to the dumpsite or to any aisle or place to get burned knew about the program.

5.2.2 Collection performance

During the first days the collected amounts were little until more people gained trust and realised that this program is really taking place. Many of the stakeholders that were informed ahead were hesitating to believe this purchase program would be implemented as they had been requested to participate in other collection programs previously that never materialized. Strong people, who usually carry bags of waste on their shoulders or on trolley carts to the different disposal locations, now brought huge bags up to 100 kg full of textile waste to the collection point. Not only the usual waste transporters but also individual sweepers working at the market brought bags, even just 4 or 5 kg with textile waste that they swept from the tiny alleys of the market to make some extra money. The news spread quickly and so the amount of waste delivered increased daily. After a few days of collection, the amount became predictable and consistent. Figure 13 displays the amounts of textile waste delivered during the 10-day incentive-based collection campaign. The average daily delivery after the launching period was approximately 4 t. The total delivery was 26,5 t during the one week that the reception was fully operational. The total delivery amount (including the launching period Dec 8 – 12, 2023) was 30,5 t. The maximum delivery was on Monday Dec 18, 2023 with 4,4 t.

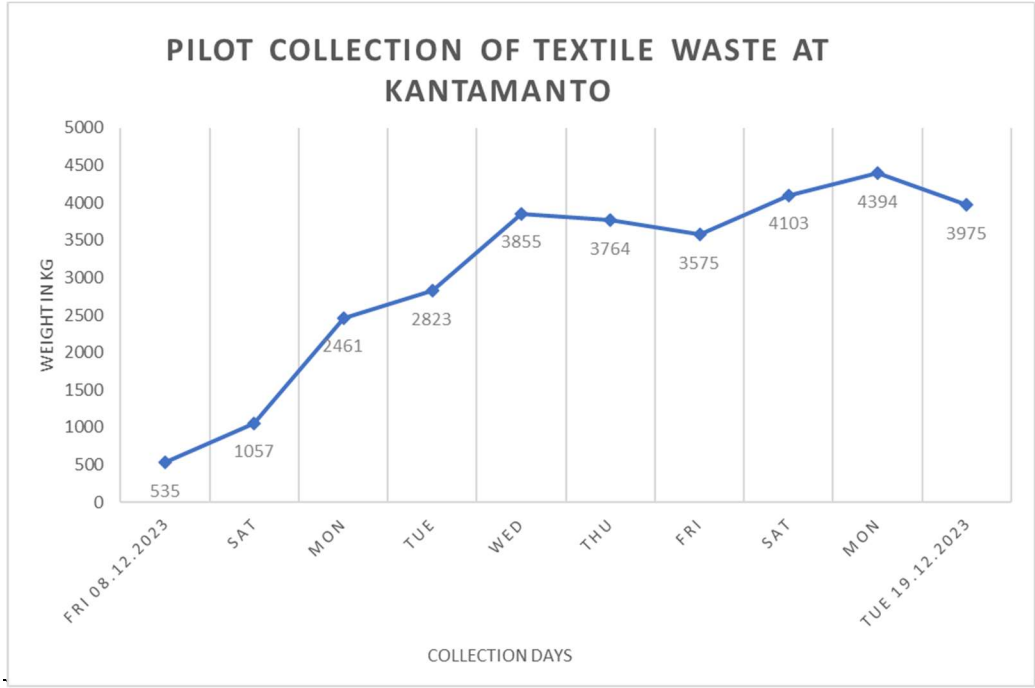


Figure 13: Incentive-based textile waste collection – daily amounts

The initial plan was to collect up to a total of 100 t and to determine how long it would take to accomplish this quantity. It was expected to take just a few days in light of the claim that every day 100 t of waste are generated. The program was adjusted and ended as planned after 10 days, however, amounts were still far away from 100 t.

The following conclusions can be drawn from this trial:

- The pilot collection confirmed the observation that the waste generation is far below 100 t textile waste per day around Kantamanto market.
- Although the collection was only a spot check for a few days, and certainly there might be seasonal variations, it still was a test over a period sufficient to collect reliable data. In several interviews with the engaged people at the market, it was confirmed that despite some variations, in general, the amounts of waste generated are not significantly different from what was generated during the pilot test.

- It was observed that usually the waste transporters delivering the market waste to the official collection truck of Zoomlion even pay a tipping fee to the supervisor. During the purchase program instead of paying money, they received money for their waste.
- Even though the market has been inspected, and no more waste was found after the collection had been finished, certainly not every single garment was caught through the purchase program. Some garments were probably still used for a different purpose (e.g. to light a fire for heating up the showers at the market). Therefore, for the calculation below in chapter 5.4 this assumption has been considered and a security factor of x-2 was added for all waste that might have been generated but was not collected.
- It is most likely that despite the small money offered as incentive, not only clothes from the Quality 4 (ultimate waste) were received through the purchase but also some stocked garments of Quality 3, which have been considered difficult to sell by retailers (or at least not for a better price). This assumption was to be confirmed by the subsequent waste composition analysis.

5.3 Waste composition analysis

Once the collection was finished, the huge volumes of textile waste had to be sorted by hand in order to determine the composition. For this purpose, a practical sorting approach was executed that allowed managing the collected amount in a reasonable effort and time.

Figure 14: Storage of collected textile waste

After a training session from The Revival, 13 volunteers sorted all the textile waste that was stored in polyvinyl bags of 50 – 100 litres at the storage area (Figure 14). In the first step the cutting waste was separated from all other SHC waste and the whole amount of garments was separated in “good” (technically rewearable, characteristic for Quality 3), “bad” (non rewearable garments representing Quality 4) and cuttings. The result is presented in Figure 19. Almost half of the amount was cuttings, which was unexpected. The Quality 4 (waste) represents about 15 %. A remarkable fraction with 47 % of the overall total is cutting waste from the tailor and sewer section Figure 17. This waste is composed of cuttings of small pieces, different materials and not feasible to further separate without technology such as an NIR (Near Infrared Spectroscopy) scanner to detect each material. This fraction has also been found at the beach entangled in fisher nets and other waste accumulating to big tentacles as illustrated in Figure 18. From the remaining fraction that is not cuttings, 71 % can be considered **Quality 3** that is still wearable in its original form, but unsellable at the local market (wrong sizes, styles or winter clothes). **Quality 4** with non wearable, dirty, moulded or torn clothes represents 29% of the disposed of waste-

Figure 15: “Good” waste/quality 3 (winter clothes)

Figure 16: “Bad” waste/quality 4 (non rewearable)

Figure 17: Mixed cutting waste from tailors

Figure 18: “Tentacle” – mingled waste and fishernets at Kokrobite

Figure 19: Quality composition of textile waste

In a second step, a representative sample has been taken which was spread and quartered before it has been sorted in the following categories.

- Cotton and cotton-rich
- Mixed fiber with low cotton
- Viscose
- Synthetic (pure Polyester, pure Acrylic, other mixed fibres)
- Denim
- Leather

After the detailed sorting of the sample the total volume of all bags has been sorted in a less detailed approach, separating cotton (-rich) from synthetic fibre, by touch feeling and checking the labels of each garment as far as possible. As mentioned also by other organisations (The OR Foundation, 2022), there is no way to identify the fibre type of every garment. The result of the detailed waste sorting analysis is presented in Figure 20.

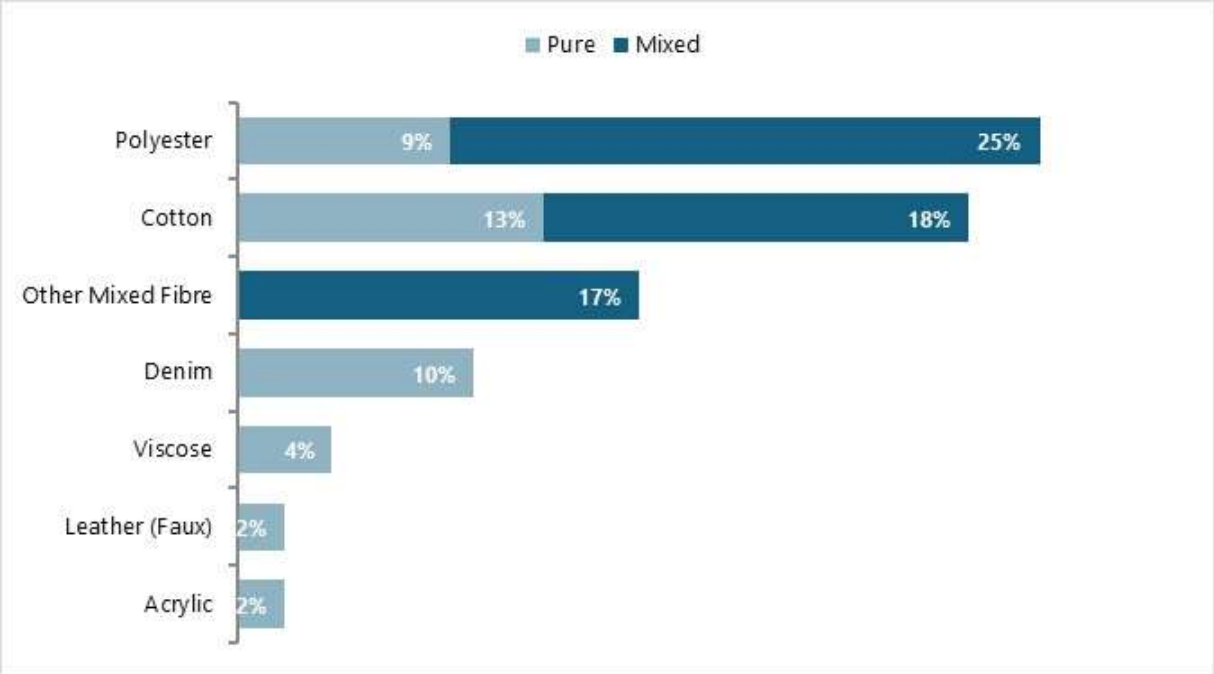


Figure 20: Detailed quality composition of textile waste (excluding cuttings)

The waste composition provides a good data set for any further technology application and project development. It can be seen that about 28 % are pure fractions (100 % single textures) with Polyester (9 % portion) and Cotton (13 %) in a significant extent, while Viscose (4 %) and Acrylic (2 %) are small fractions. 18 % are Polycotton blends with minimum 60 % cotton content. 17 % are mixed fibres, mostly synthetic, 10 % Denim (which is also a cotton rich material)

The results are different from previous analyses, which found more pure cotton in the waste (for instance: vs. 35,9 % vs. 13 % by (The OR Foundation, 2022). This may be due to different collection schemes. The OR Foundation did their analysis upstream at the retailers end where the garments just begin their transformation into waste, while the analysis of this study was done downstream when leaving the market. It can be speculated that eventually a significant share of the cotton material has been seen as a resource and thus has already been removed and sold as rugs instead of becoming waste at the market.

It should be noted that the Quality 4 components of the textile waste (non rewearable) may arrive at the collection points in very poor condition, which can have a negative impact on the further processing. It is not clear at what time of their journey the clothes have become that dirty (Figure 21). It should be further noted that it is not clear whether the garments have been recently shipped or whether they were already worn for a longer period in Ghana with a second-hand user.

Figure 21: Quality 4 textile waste from Kantamanto market

5.4 Observations, Results and conclusion

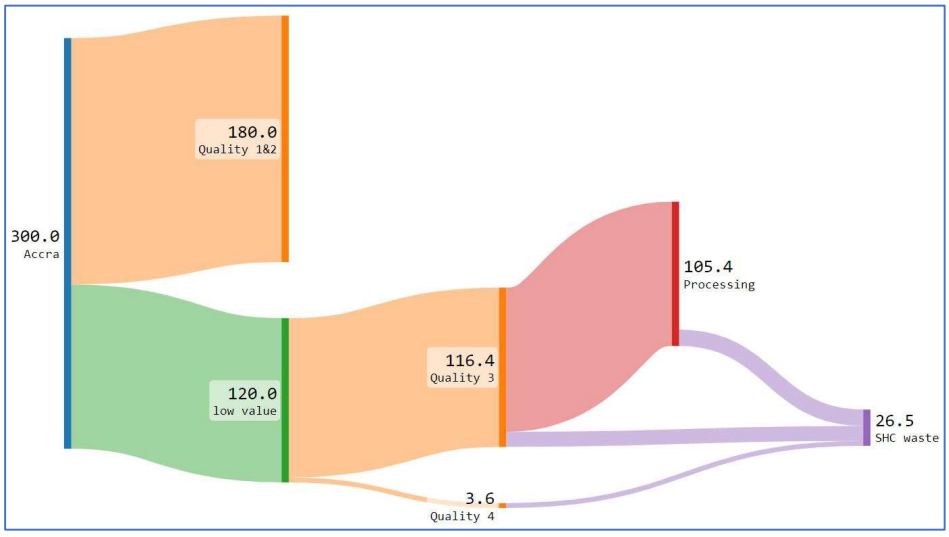
Considering the collected waste that shall be targeted for a business case, it sums up to a daily amount of maximum 4 t. This quantity is considerably less than numbers previously communicated by other stakeholders around Kantamanto market. Amounts were claimed of 70 t/day up to 100 t/day. Currently, the consultant is not able to present a robust justification despite some systemic faults. For instance, the amount of waste was previously estimated based on truckloads (The OR Foundation, 2022: 2 waste truckloads per day), which were estimated to have 35 t payload. In fact, the weighing data during the collection campaign indicated that the payload of a full large tipper truck was as low as 4 t. The observations lead to the conclusion that the collected amount during the purchase program is an overall reasonable number for the textile waste generated at Kantamanto market.

The 26,5 t of textile waste per week translates into a waste portion of almost 10 % assuming that the estimated amount of 300 t/week of traded second-hand clothing at the market is correct. However, all numbers still incorporate some uncertainties. In case the traded amount is higher than 300 t/week, the 26,5 t/week of waste would appear too low.

Figure 22 Truck loaded with 4 tons SHC waste

Even when applying a safety factor of x-2 for considering uncollected materials during the collection campaign seems to result in realistic numbers doubling the waste amount to 53 t/week for later development of projects. As the consultant is confident about the collected field data, the safety factor of x-2 can be considered as rather conservative.

The Sankey diagrams (Figure 23) illustrates the material flux for the SHC at the market considering the results of the investigation. As stated above 120 tons per week of low value SHC are traded at the market, but only 26,5 tons (or 53 t respectively) are textile waste. Out of these amounts of textile waste a minor portion of 3,6 t (8 t respectively) or 15,4 % are waste for technical reasons (quality 4), while 37,3 % are re-wearable (thus quality 3), but without value. Given those numbers are correct, about 105.4 t/week out of quality 3 are being processed (upcycling, repair etc.), otherwise they would have ended up in the collected waste sample. During the processing the cuttings are generated, which were found and had been disposed and collected (47,3 %). Once applying the safety factor x-2 resulting in 53 t per week of waste, still a significant portion of quality 3 (91 t per week) is processed (Figure 23 lower).



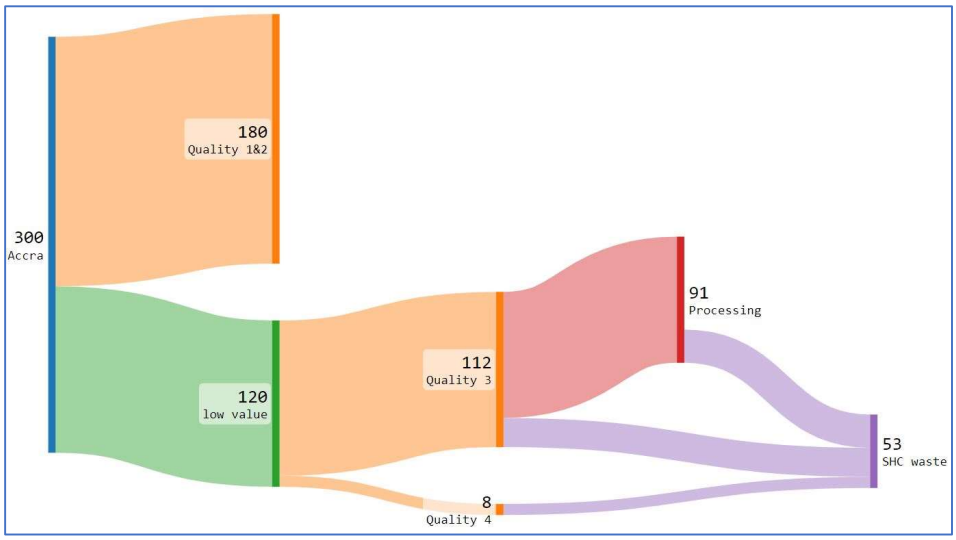


Figure 23 Mass flow based on trial collection and with safety factor 2 for SHC waste

The results of finding a comparably small amount of waste give space for some alternative explanations about the local SHC situation. (i) The quality of bales is possibly higher than assumed resulting in less low-value SHC, (ii) the recycling and reuse quota of the quality 3 material is probably higher, and other options. Some of those explanations seem to be rather unlikely, for instance retailers complain about decreasing material quality. Anyhow, regarding future project measures the sorting results provide a good starting point.

Some final notes should be acknowledged:

- As the focus of this study has been the Kantamanto market environment, no detailed analysis of the other SHC pathways has been conducted. Kantamanto might be the location where the biggest concentration of SHC waste is generated. However, this waste is generated from the traded garments that represent only a share of the overall SHC imported to Ghana. The remaining SHC is distributed around Ghana and into neighbouring countries, where it also may cause environmental problems.

- In general, an improved waste management system focusing on an effective collection covering all households including poor neighbourhoods would have the biggest potential for improving the emission and littering situation. A separate collection of textile waste across major cities could be a second step to catch most of the garments before entering the environment. Implementing a collection at markets such as Kantamanto in Accra, or in Kumasi or Takoradi as a starting point could be an effective option to be piloted.

6 Circular economy options for textile waste

6.1 Overview

Textile recycling embodies a crucial aspect of the circular economy, fostering sustainability by redirecting used textiles away from landfills. This process involves systematically collecting and categorizing discarded clothing and fabrics, creating a closed-loop system where materials are repurposed for new products. Through methods like mechanical and chemical recycling, used textiles are transformed into secondary raw materials, minimizing the need for virgin resources. This not only reduces the environmental impact but also addresses the negative effects of fast fashion and excessive textile waste. Embracing textile recycling as a key component of the downstream circular economy promotes a more responsible and resource-efficient approach to the lifecycle of textiles.

In Ghana, a significant portion of affordable clothing finds its way into the local market through imports from outside the country. While Ghana boasts a rich textile heritage and a growing fashion industry, a considerable portion of the affordable and readily available clothing is sourced from international markets. This reliance on imports stems from factors such as cost-effectiveness, convenience, and the globalized nature of the fashion industry. Second-hand clothing, often originating from countries of the global north, plays a prominent role in this landscape.

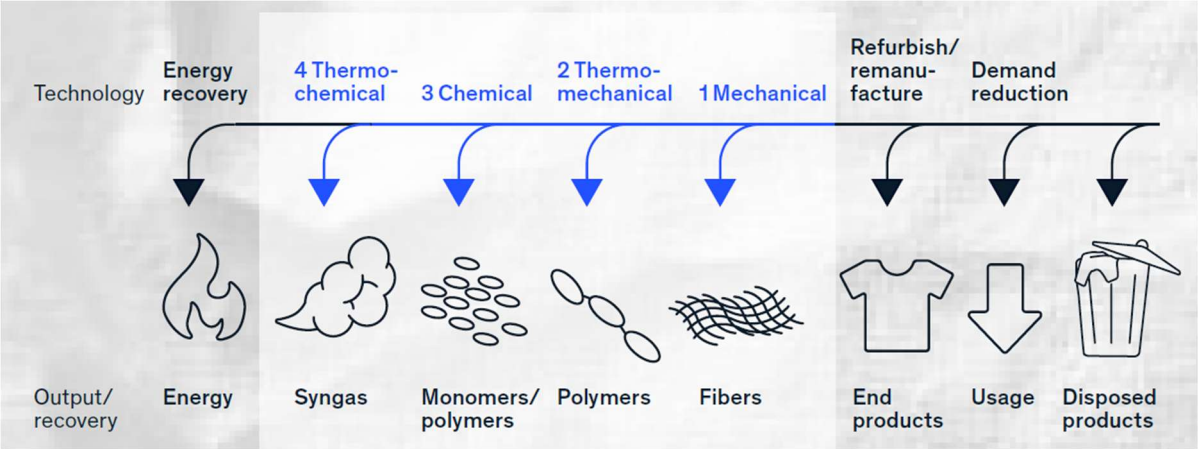


Figure 24: Life cycle of discarded textiles (McKinsey, 2022)

Discarded textiles undergo various processes, including upcycling, recycling, and downcycling; each contributing differently to sustainable resource management (illustrated in Figure 24). **Upcycling** involves creatively transforming used textiles into higher-value products without breaking down the material's integrity (Figure 25). This approach often leads to unique and innovative items, such as repurposed clothing or accessories, minimizing waste while adding value. In some cases, the products of Ghanaian upcycling designers are sold in Europe. **Recycling**, on the other hand, entails breaking down textiles into raw materials, like fibres, that can be used to manufacture new products. Mechanical and chemical recycling are common methods, emphasizing resource conservation and reduced environmental impact. **Downcycling** involves converting textiles into materials of lower quality, typically due to the degradation of fibres during the recycling process. While it may not retain the original material's quality, downcycling still contributes to waste reduction. Moreover, it plays an essential role as the degradation of material and length of fibre for instance, are dominant issues.

Figure 25: Upcycling product – Bag made from Denim waste

Different methods can be applied to each material to recycle it. These methods can be categorised as chemical, thermomechanical and mechanical. Each of these categories has certain treatment steps that must be performed to reach the desired product.

Material preparation stages within the **chemical recycling**:

- Grinding
- Selective dissolution – plastic waste is dissolved using solvents and heat to extract the polymers (and additives) (The EU Chemical Industry Transition Pathway, 2024)
- Chemical / enzymatic depolymerization – enzymatic depolymerization promises to not produce "second pollutants" when dealing with PET (Brivio & Tollini, 2022)

Materials integration processes within the chemical recycling:

- Cellulosic pulp production
- Cellulose regeneration / viscose
- Chemical spinning - the process of making man-made filament fibre yarn
- Monomers

As the European Recycling Industries' Confederation (EuRIC) reports, reaching the stage in which recycled fibres have comparable features to the ones of virgin fibres is not yet at a commercial scale, though these technologies will reach maturity level and a stage of scale-up provided that the appropriate legislation is in place (EuRIC, 2021). Moreover, the EuRIC identifies challenges of chemical recycling regarding the yarn length and their dye, which cannot be removed and the labour-intensive removal of disruptors.

Material preparation stages within the **thermomechanical recycling**:

- Compounding, densification

Materials integration processes within the thermomechanical recycling:

- Fibrous fillers – characterized by short-discontinuous fibres (inter alia polyaramid textile fibers)
- Polymer blend
- Chemical spinning
- Pelletizing

The mechanical approach to recycling involves a sequence of production steps: including cutting, blending, and opening. Machinery in mechanical recycling processes, generally-speaking, transforms the material into smaller pieces, which presents itself as problematic, when talking about the fibre length.

Material preparation stages within the **mechanical recycling**:

- Coarse grinding / shredding
- Manual or mechanical cutting
- Chopping, garnetting /tearing
- Chopping, unravelling – a process of disentangling the threads of woven or knitted fabric

Material integration processes within the mechanical recycling:

- Mixing dosage
- Carding – a mechanical process that disentangles, cleans and intermixes fibres
- Carded spinning, Open-end spinning
- Thermobonding / spunlacing, Thermoforming
- Mechanical needle punching
- Airlay laying- Web forming is a method where fibers are scattered into fast-moving air and pressed onto a moving screen using either pressure or a vacuum (Zhang, 2010)
- Cross-lapping, Fine grinding, Pelletizing
- Additive / Fillers – Fillers, non-soluble additives improve the mechanical and electrical properties of a material. Unlike fillers, additives are soluble. (hp-textiles, 2024)
- Molding / injection or compressing - Compression molding is a manufacturing process where a preheated material is placed into a mold cavity. The material cools and solidifies, taking the desired shape. (moldie.net, 2023)

Closed-loop recycling, aiming to convert textile waste into reusable fibres for new material production, faces significant challenges hindering its widespread adoption. Mechanical closed-loop recycling, which imposes strict material processing requirements, makes it challenging and costly for recyclers to source suitable feedstock, often resulting in weakened fibres that require blending with virgin fibres. Meanwhile, chemical closed-loop recycling addresses tough-to-recycle materials but is still in its early stages with limited processing capacities and economic viability. The scale required to handle diverse materials and waste volumes has not been achieved (Khandelwal, 2023). In the context of feedstock availability it should be mentioned that polyester and PET are similar materials in chemical composition, thus co-processing of those materials is technically possible. However, other technical and legal limitations regarding different handling (stiff flakes vs. fluffy fabric) and legal regime (textiles are not allowed in PET bottle-2-bottle recycling).

6.2 Synthetics

Synthetic textiles offer versatile possibilities through various processing methods: chemical, mechanical, and thermomechanical recycling. Figure 26 illustrates available technologies and potential products for recycling of synthetics (follow the blue line in the figure). In chemical recycling, synthetics can be ground and further processed to create yarn for woven or knitted fabrics, as well as plastics for packaging. Thermomechanical recycling involves compounding the material to fibrous fillers and polymer blends, which can be pelletized or spun for use in textiles (such as yarn) or plastics production.

Mechanical recycling encompasses a broad range of methods, including grinding, shredding, cutting, garnetting, tearing, and unravelling. In a subsequent step, processes like spinning, carding, lapping, compressing, and molding can transform synthetics into fuel, composite materials, housekeeping wiping cloths, padding for furniture, automotive components, and nonwovens for insulation and building decoration (Recycle Re_fashion, 2022). Even though the recycling of synthetic material is de facto possible, it does not take place at scale in Europe (EEA, 2023)

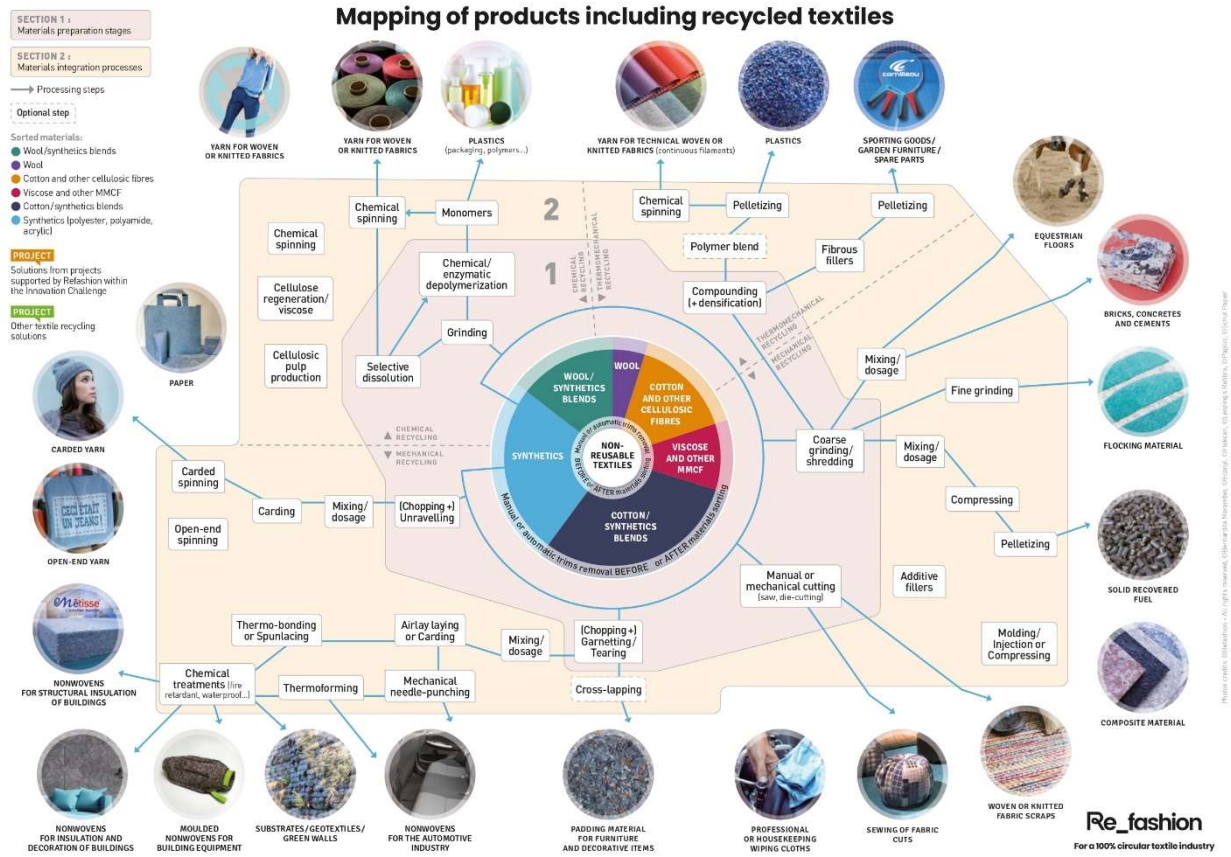


Figure 26 Mapping of products from synthetic textiles

6.3 Wools and wool-synthetic

Non-reuseable textiles made from pure wool are only mechanically recycled; grinding, shredding cutting chopping, garnetting/tearing, unravelling is the first stage of processing the material. Through different secondary processes (carding, air laying, thermo-bonding, spunlacing, pelletizing, etc.) various products can be generated such as carded yarn (lower quality yarn), nonwovens for insulation, decoration and the automotive industry, padding material, fabric scraps or solid recovered fuel from wool (Recycle Re_fashion, 2022).

Wool-synthetic blends undergo mechanical recycling. The different material mix demands additional processing steps, allowing the development of molded nonwovens for building equipment, which is not feasible for pure wool. Potential technologies and products are mapped in Figure 27.

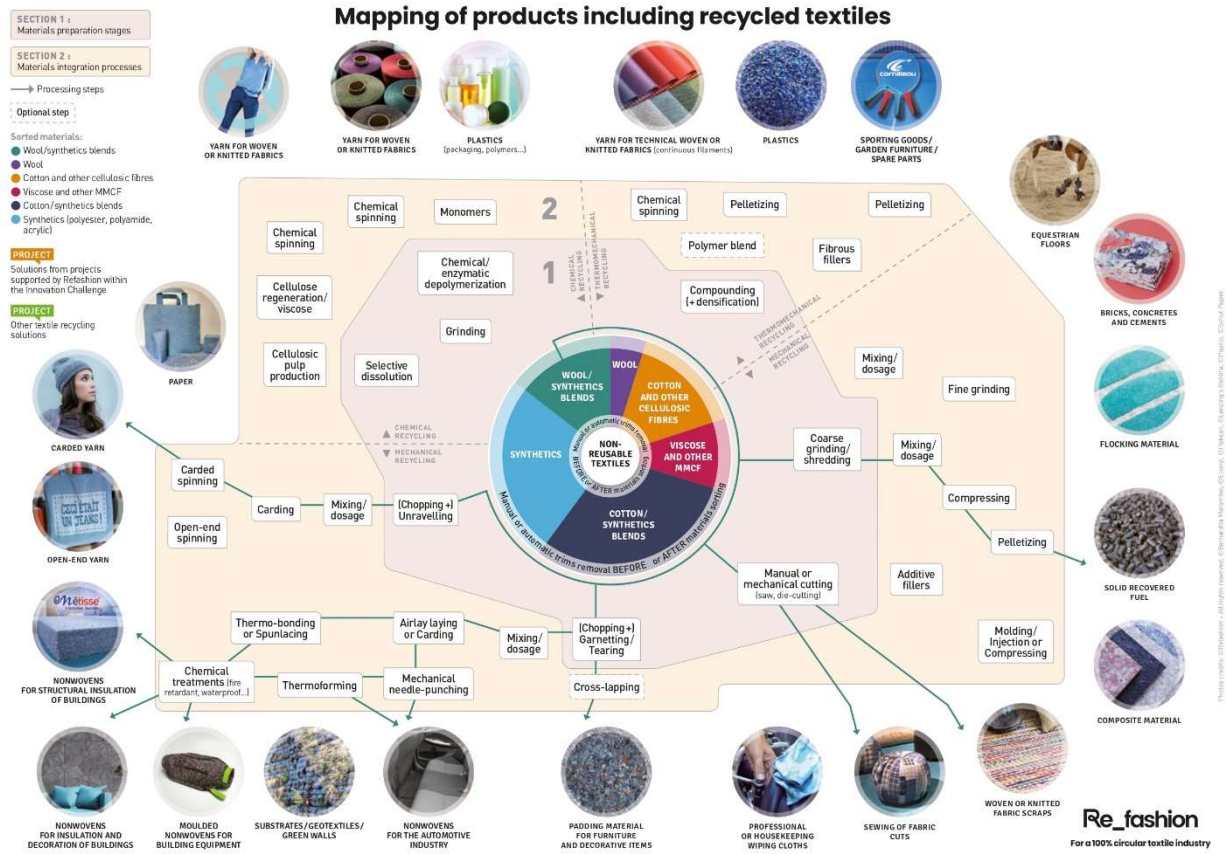


Figure 27 Mapping of products from wool-synthetic textiles

6.4 Viscose

Viscose, derived from cellulose, can undergo chemical or mechanical recycling. In chemical recycling, the process involves grinding, selective dissolution, pulp production, and chemical spinning to produce yarn for fabrics. Mechanical recycling yields diverse products such as equestrian floors, flocking material, solid recovered fuels, fabric scraps, padding material, nonwovens for automotive and building industries (primarily for insulation and decoration). Additionally, recycled viscose can be used to create molded nonwovens for building equipment, substrates/geotextiles, and green walls (Recycle Re_fashion, 2022). Potential technologies and products are mapped in Figure 28.

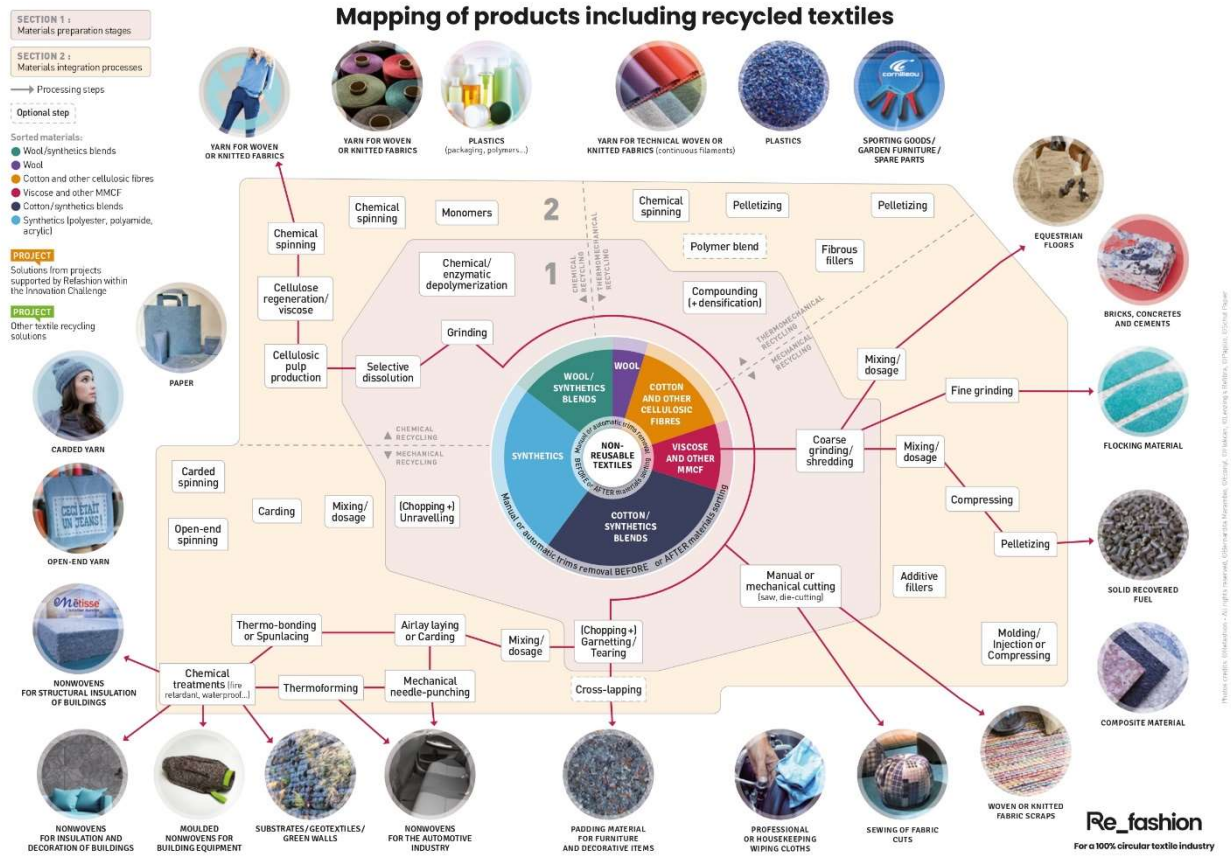


Figure 28 Mapping of products from viscose

6.5 Cotton-cellulose and cotton-synthetic

Cotton-cellulose, recognized for its abundance, strength, and biodegradability offers three recycling methods: chemical, thermomechanical, and mechanical. This versatility results in various potential products, including yarn (including Carded and open-end), nonwovens (for building, automotive, and interior design), padding materials, flocking material, equestrian floors, bricks, concrete, cements, sporting goods, fuel, and more (Recycle Re_fashion, 2022).

Synthetic cotton is equally recyclable as cellulose cotton, with an added option for chemical recycling to separate synthetic and natural cotton. This separation allows the development of additional products, such as packaging. Potential technologies and products are mapped in Figure 29.

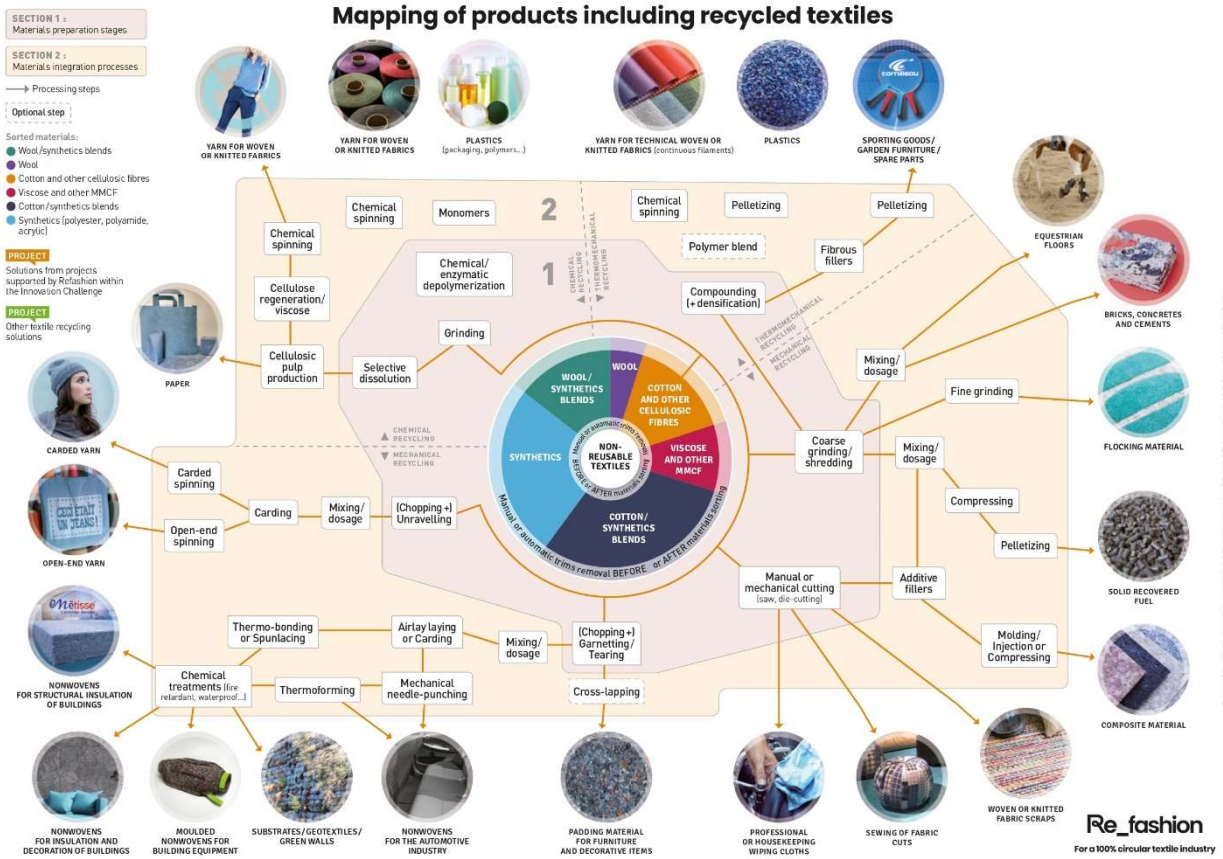


Figure 29 Mapping of products from cotton and other cellulosic materials

7 Potential circular economy measures in Ghana

7.1 Overview and conclusion from field investigations

Industry professionals managing second-hand clothing and defective goods observe a lack of sufficiently scaled recycling infrastructure in Germany to handle the substantial material volumes. While acknowledging small pilot projects, they report that the dominant practices involve sorting second-hand materials within Europe (e.g., The Netherlands and Poland) into different and numerous categories, based on their clients' wishes, followed by selling them to non-European markets. However, defective goods (returns) are directly brought out of the European market. This policy aims to prevent these goods from re-entering the European market at reduced prices (Interview1, 2024).

Similar information can be reported (e.g. for India's textile industry) also facing the issue of available technologies but lacking investments as investors do not see a desirable outcome yet (Fashion for Good, 2022).

Generally, the suitability of textile waste for recycling is based on different aspects, such as the material composition of the fabric, the presence of disruptors in the material that can be removed and not removed, and the color in the fabric. Moreover, it is of concern to design the recycling process to reduce harm to the environment and human being.

Based on the field results (chapter 5) the following three options of dealing with textile waste have been identified as the most feasible and promising approaches for this project:

- Biochar from cotton
- Refuse-derived fuels (RDF)
- Thermomechanical recycling of synthetics

These three technology ideas encompass distinctly defined processes, which shall be later follow up with when developing potential business cases. These three specifications have been selected as they align with the observed situation on the ground particularly regarding the material composition of the textile waste and the respective amounts. Further, the technologies match the primary project goals targeting textile waste with regard to reducing amounts for disposal and minimizing emissions and pollution caused by textile waste. The selected options address both (i) paving the way towards the establishment of a high quality closed-loop recycling system and (ii) reducing large quantities by means of energetic utilization.

Beside the above mentioned full chain technologies, additional accompanying processes are worth mentioning as they are useful to overcome barriers in implementing recycling technologies. The main bottlenecks are sorting (including identification of suitable feedstock materials) and shredding to adequate fiber size. In particular shredder capacities and effective equipment is hardly available in Ghana. With regard to technologies, it is less of a technical challenge, because adequate shredding technologies and equipment are available in global north countries. The major hurdles come from lacks in financial capacity, organizational set-up and other factors, which should be addressed as circular economy measures.

7.2 Biochar from cotton

Biochar is a type of charcoal produced through pyrolysis of carbonaceous materials, a process of heating material up to 500 °C without oxygen. Pyrolysis has gained attention as a sustainable waste treatment process, also ensuring lower net greenhouse emissions than conventional energetic recycling processes (e.g., incineration). In general, pyrolysis can be applied for mixed waste as well as for pure organics. Differing from a feedstock of mixed waste, a feedstock of pure organic carbons generates high end products (biochar) with low process emissions. The sustainability of this process certainly depends on many aspects.

Overall, Biochar can further be used as

- soil enhancing material, returning valuable nutrient to the soil (Mower, Dembele, Strezelec, & Thapa, 2022), however, this requires pure organic input material, which would disqualify material with disruptors, or otherwise a pre-process must take place to avoid the inclusion of microplastics into soil. Clean biochar is a suitable base material for preparing Terra Preta.
- a substance to improve the performance of clothing, regarding moisture transfers, drying properties, water vapor and air permeability, and odor adsorption (Cay, 2020)
- A material to adsorb reactive dye (Parmakoglu, 2023)
- Electrodes for sodium-ion batteries and supercapacitors (Lee, 2023)
- Cement fillers (Lee, 2023)

The advantages to this treatment process are the possibility that the feedstock can be heterogenous (Lee, 2023), if it is not foreseen as a soil enhancer. Additionally the process is rather simple.

The Ghanaian universities, University of Cape Coast and the University for Development Studies, conducted research on the adsorptive manner of with biochar and biochar as a removal material for reactive violet 5 (Tulashie, 2023), which is a coloring used for textile, fabrics and paper-printing industries.

7.3 Pre- & co-processing RDF

Following the common understanding that avoiding and reducing waste is the best way of dealing with current waste problems all over the world, pre- and coprocessing respects the waste hierarchy and does not contradict it, when following certain guidelines (Holcim Technology Ltd and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, 2020).

In this context, it can be classified as a technology for energy recovery and mineral recycling. Holcim Technology Ltd & GIZ GmbH (2020) promote an approach that aims to reduce existing waste problems and, at the same time, to encourage the use of waste as an alternative source for primary energy and virgin raw materials in cement production. Wherever possible, the concepts of resource efficiency, circular economy, recycling and reuse must be given priority.

This technology, however, is not to be confused with the concept of waste incineration plants that only exist for the purpose of processing waste and aside also generate heat and electricity, depending on the specifications.

It is important to note that processing textiles into RDF requires thorough consideration of the characteristics of the textile waste, most of all to ensure that the chosen material cannot or will not be used for something else anymore. Technical aspects such as fibre types, contaminants, and other factors do also come into play. The equipment and processes used should be tailored to handle textile waste effectively while meeting environmental and quality standards. Additionally, regulatory compliance and adherence to best practices in energetic recycling operations are essential aspects of establishing this recycling process. Essential aspects are:

- Composition of material
- Calorific value
- Moisture content
- Particle size distribution
- Contaminants levels
- Collection and transportation to the plant

The process of RDF production foresees several key steps. Firstly, if the feedstock is heterogeneous a sorting must take place to remove recyclables and non-combustible materials. This step is followed by the shredding of the feedstock to enhance the combustion efficiency. To develop a refined fuel for the kiln, the shredding process is followed by a screening of material and a quality check (mostly on calorific value and moisture content).

Notably, this technology contributes to GHG reduction by reducing the need for fossil fuels that is usually used in cement kilns. This is aligning with circular economy principles and Sustainable Development Goals. With the use of the textiles as RDF, and with the value that is hereby given to the otherwise discarded textiles, textiles are less likely to be littered and they can be diverted from the landfill. Processing mixed post-consumer textile (PCT) waste to RDF has a low level of complexity in regard to feasibility and implementation in short time. Despite the requirements for feedstock materials mentioned above, compared to more sophisticated recycling technologies, co-processing allows to transform big amounts of non-recyclable materials into a product that is substituting fossil fuels.

Considering the current landfill situation in Accra and surroundings, this way of dealing with discarded clothes is more environmentally friendly, assuming that the RDF process is performed properly. Concluding with the perspective that with RDF as an option of recycling, there will be reduced littering and, consequently, less uncontrolled discharge of plastic, microplastic and pollutants from fabric and dye into the environment, both land and sea (Bianchi, 2023). Additionally, textiles are diverted from the landfill or spared from burning at the Kantamanto market directly, which also would lead to less environmental harm.

In Ghana, there is currently no cement kiln suitable to feed in RDF. However, cement companies are willing to modify their kilns if there is a perspective of constant feedstock supply of RDF that justify an investment in a suitable feeding system for the kiln.

For the present project, a cooperation agreement with Heidelberg Materials (formerly Heidelberg Cement) has been initiated in order to prove the suitability of textile waste as feedstock material in the cement kiln in Tabligbo (Togo), which has the necessary specifications and is located only 250 km north-west of Accra.

7.4 Thermomechanical recycling of synthetics

7.4.1 Polyester

Synthetic fibers are extensively utilized in the textile industry due to their excellent processability and mechanical properties. Their versatility is evident in a wide array of applications, spanning from everyday clothing to technical textiles. These fibers are chosen for their ability to meet specific performance needs, making them a common choice in various sectors, including sportswear, outdoor gear, and industrial applications (Bianchi, 2023), (van Duijn, et al., 2022).

Polyesters, characterized by the ester functional group in their main chain, are a diverse group of polymers. In textile applications, the term 'polyester' commonly refers to polyethylene terephthalate (PET), which dominates over 50% of the global synthetic fiber market (Bianchi, 2023). Clothing often contains a blend of materials, including polyester, posing challenges for recycling. Sorting the different synthetic fractions is necessary for recycling. As described above the textile waste samples at Kantamanto market contained 9 % pure and 25 % mixed polyester fabrics.

Chemical recycling of waste textiles containing Polyethylene terephthalate (PET) through depolymerization is seen as a promising, but yet to be upscaled technology. This process generates oligomers or monomers that can serve as substitutes for those derived from fossil resources. PET produced through the polymerization of these recycled monomers has the potential to match the quality of virgin materials. Moreover, the monomers derived from recycled polyester can replace fossil-derived chemicals in the production of various value-added materials. While PET is the predominant polymer in polyester textiles, co-monomers and different polyester types may be present, influencing specific properties, such as dyeability or flame retardance (Bengtsson, 2022). This process is mostly oriented towards the recycling of individual fiber types, while textiles often have a high diversity of materials to fulfil certain functions (Textile Technology, 2022). A German startup, Rittec, has recently reported a method for breaking down old fabric into components, achieving this in 95% of cases at 160°C. The process supposedly eliminates impurities, allowing the recycled polyester to be used in fiber production with comparable quality to virgin material, presenting a closed-loop approach to recycling (Flustix , 2022). However, the industry perceives polyester (and blends) as an unfavourable material due to the general absence of fiber to fiber technologies at scale (Fashion for Good, 2022).

Thermomechanical recycling is deemed to be the most prominent method when talking about synthetic fiber (including PET, polypropylene, polyamide, etc.). Besides the different technologies that can be followed, the synthetic material is mostly re-melted and turned into granules, which can then be used for thermoforming or injection-molding of items for the automotive industry, household appliances, protection applications, garden furniture, leisure appliances (Recycle Re_fashion, 2022) (Bianchi, 2023). The feedstock for this process should be mostly uncontaminated, which results in post-industrial and not post-consumer textiles, amounts of elastane or cotton can disrupt this process (Textile Technology, 2022). The most sophisticated technical approach is yarn-2-yarn recycling, which requires an elastane free pure polyester feedstock material, which is difficult to be collected from post consumer textiles and, hence, from the textile waste. Moreover, in order to produce spinnable resins it is highly recommended not to mix colors as for instance a blend of red and green feedstock fibers may harm the extrusion process. The input material may be a mix from textiles and PET flakes (from bottle recycling), however PET recyclers are not too much interested in adding polyester fibers due to problems in handling.

7.4.2 Polysynthetic (commingled) feedstock

Currently in Ghana, there is no active textile thermomechanical recycling technology. For other waste plastic materials this recycling exists on a rather small scale with companies like Miniplast. However, PET is not recycled and only prepared for export. The recycling company Pyramid Recycling, however, already experimented with very different plastic materials and is producing its products from purely recycled plastic without additional virgin material. For the mixture based on different materials, PET is also being used and the first tests to substitute PET by synthetic textiles were positive. Currently, further tests are conducted regarding the suitability of also blended textiles.

Figure 30 Outdoor furniture made by Pyramide Recycling from its plastic lumber

7.5 Development of business cases

The final objective of this project is the development of potential business cases, which may receive further support by GIZ and other partners. Based on the field observations and investigations, as well as considering the assessment of potential technologies a number of business cases have been developed.

- Yarn-2-Yarn recycling of polyester
- Improvement of thermomechanical recycling for polysynthetics
- Cotton-2-biochar
- Substitute fuels (RDF) from polysynthetics
- Pretreatment of textile waste (sorting and shredding)

The various processes require additional tests and technical investigations in order to assess their feasibility and to subsequently develop business cases, which may attract partners. These activities are partly still on its way. The details for the business cases as well as the yet available results of tests are presented in a separate document which is attached to the main study.

8 Stakeholder landscape

8.1 Ongoing local project activities (third parties)

- **OR Fundation:** The Or Foundation, is a public charity in the USA and a registered charity in Ghana since 2011. It stands for choice and agency, aiming to challenge the socio-economic system of corporate colonialism. Operating at the intersection of environmental justice, education, and fashion development, the foundation seeks alternatives to the prevailing fashion model, promoting ecological prosperity and inspiring a meaningful connection to fashion beyond consumerism. Or has released several reports about the secondhand business in Ghana and its consequence. As part of their work, they seek solutions for textile waste by creative ideas for recycling and upcycling products.

- **The Revival:** The Revival is a community-led sustainable design non-profit in Ghana, leading transformative initiatives. Over the past years, they diverted 1.6 million garments from landfills and oceans, creating a global impact through upcycled products and job opportunities in Kantamanto. Their innovative approach extends to crafting protective uniforms for farmers and providing free online courses, benefiting over 2.500 students worldwide. With a vision for sustainable fashion, The Revival aims to establish Africa's first Recycling and Upcycling facility, creating employment for over 600 people. The Revival has been the local partner organization for the pilot collection of textile waste from Kantamanto market for this study. They believe, with their experience and network they could support the development of a collection system for textile waste at Kantamanto market and depending on potential funding even being engaged in its operation.

8.2 Local companies in textile recycling sector

- **Miniplast:** Plastic producing company. In discussion with Remondis and H&M about extension of plastic production, considering also synthetic textile fibers for their plastic products. Currently, Miniplast is not recycling PET, they only condition and export PET. An upgrade of the production line is necessary to process nylon and polyester fibers that are similar to PET.

- **Akosombo Textile Ltd**: Producer of African wax print from cotton material. Currently, they are in discussion with investors to expand the production line. Their vision is to implement a sorting plant for mixed textile waste. Cotton and cotton-rich materials could be used to blend their fabrics, all other textile waste might be exported or incinerated in their steam generator.

- **Pyramid recycling**: An enterprise that deals with the collection of recyclable and non-recyclable plastic waste materials and turns them into innovative valuable products such as curtain rope, chair fittings and “Wood plastic”. All products are made without virgin plastic material. The composition recipe with different plastic types has been developed over several years in order to produce durable products. First tests, including synthetic textile fibers (polyester, nylon), were positive. With further tests and investment in machinery (shredder, extruder) 300 kg of synthetic textile waste could be recycled.

- **Trashy Bags Africa:** A Ghanaian company that upcycles plastic water sachet bags into different products e.g. carry bags or laptop cases. For their products, they also upcycle (mostly African wax) textile waste.

- **King recycling solutions**: A local entrepreneur that seeks affordable feedstock of cotton and cottonrich textiles. The garments are processed by cutting of disruptors such as buttons and collars before they are baled in 350 – 420 kg bales and exported to Europe for recycling as cleaning rugs. The garments suitable for cleaning rugs are often specific and dependent on the requirements of the client. Garments that are usually considered to be recycled are:
    - Colour T-shirt, sweater
    - Cotton trousers
    - Colour cotton shirts, sheets, towelling
    - White T-shirt, T-shirt print, sweater, cotton shirts, bed sheeting, towelling

- **Do The Right Thing (DTRT):** A local garment manufacturer, able to operate on an international level in terms of size & efficiency. With 5.000 employees they are the largest apparel exporter in West Africa and producing exclusively for export to the US. During the production of garments, made from synthetic fibers, a daily amount of 5t of cutting waste is generated. DTRT is seeking sustainable solutions to process their production waste.

8.3 Potential international partners

- **Work Studio and Paneco:** Paneco boards are made from used clothes. Work Studio has been seeking how they can work together with the fashion industry in Ghana to tackle fashion waste issues since 2022. They work in collaboration with relevant stakeholders on the ground. Their eedstock material can be pre- or post-consumer textile waste, including second-hand textile waste e.g. from Ghana. However, heavily dirty waste recovered from landfills or beaches are not suitable. There are no requirements in regard to the material composition of the textiles but disrupters and hard parts need to be removed from them.

- **Renewcell:** Renewcell is a Swedish company specializing in sustainable fashion and circular economy solutions. Renewcell is known for its innovative approach to textile recycling, particularly in the field of cellulosic materials such as cotton and viscose. Renewcell's main focus is on developing and commercializing technologies that enable the recycling of textile waste into new, high-quality materials. Their flagship product is Circulose®, a recycled fiber produced from discarded textiles. This process involves breaking down used cotton and viscose garments into a pulp, which is then used to create new fibers for textile production. By recycling textile waste, Renewcell aims to reduce the environmental impact of fashion and contribute to a more sustainable and circular fashion industry. (N.B.: Renewcell declared bankrupt on Feb 24, 2024)

- **BoerGroup UMUCO**: A Europe-wide organization in textile reuse and recycling. Sees the demand for raw materials for recycling increasing. The reusing and recycling of textiles is a developed industry in Europe, but it plays little to no role in global reuse countries yet. Therefore, BoerGroup started Umucu®, an initiative that educates local entrepreneurs to set-up a network for the collection of discarded textiles and monetize the textiles.

- **Rittec**: A German startup, which has recently reported on a method for breaking down old fabric into components, achieving this in 95% of cases at 160°C. The process supposedly eliminates impurities, allowing the recycled polyester to be used in fiber production. The company is interested in bringing their technology into countries like Ghana, however, a follow-up interview will reveal more detailed information on the existing possibilities and challenges.

- **Looper Textile:** jointly owned company by H&M group and Remondis, based in Germany, the company specializes in the collection and sorting of garments from various locations across Europe. Unlike a used-garment marketplace or a recycling facility, Looper Textile focuses on preparing used and unwanted garments for the next phase of their lifecycle. Their goal is to provide these garments as feedstock to responsible companies engaged in reuse and recycling. The company plans to bring innovation to textile collection and sorting by experimenting with new collection schemes and incorporating automated sorting technologies, such as near-infrared sorting. However, the focus is on Europe, delegations of Looper Textile also visited Ghana in November 2023 in order to explore with local stakeholders if available feedstock could fit in their business model.

- **Weima**: A German company specializing in shredding technology. Weima designs and manufactures shredders and briquette presses for various materials, including wood, plastics, and waste. They have supported international development projects in the past with their products and provide technical support for demonstration tests of the current project.

- **ANDRITZ GROUP**: is a global technology company that provides various solutions for recycling pre- and post-consumer waste made from natural and synthetic fibers.

9 Key takeaways

- Germany is among the 3 largest exporters of SHC with around 500.000 t shipments per year. Ghana is among the largest 10 importers (by weight) with arrivals of about 122.000 tons per year. In terms of value Ghana ranks 5 with a trading volume in SHC of 165 million $ in 2022, what makes the SHC sector an important economic component. The United Kingdom and China are the largest SHC exporters to Ghana, while Germany's portion is little (8.000 tons year)

- Out of the 2.350 tons per week (122.000 tons per year), which are unloaded at Ghana's ports, 300 t are directed and traded with retailers at the Kantamanto market. 60 % (180 tons) are higher quality materials (category 1 and 2), which are sold quickly, while 40 % (120 tons) are low value quality (category 3) or waste (category 4).

- An incentive based purchase campaign was carried out to determine the amount of waste. Offering ½ Cedi per kg (3,7 €-cent) about 4 tons of textile waste were collected every day on average (it may include unsellable quality 3 material)

- The comprehensive waste sorting obtained that 47 % of the waste was cuttings. The material composition of the garments shows $^1/_3$ pure materials with 9% pure polyester and 13 % pure cotton. 42 % was mixed synthetics.

- Major conclusions regarding potential treatment
    - Various treatment applications for cotton yet take place (i.e. not the main problem)
    - The large portion of mixed synthetics requires mass oriented treatment (energetic)
    - Sufficient portion of pure polyester feedstock to be used as feedstock for high end recycling
- Main challenges:
    - All processes require sorting and shredding
    - Identification of fabric by label is not reliable, no suitable procedure for cuttings, better sensors needed
    - Limited shredding capacity available on site
    - Sorting and shredding costs (50+ $/t) put pressure on the financial feasibility
- 5 business cases were further investigated (ongoing):
    - Yarn-2-Yarn recycling of polyester
    - Improvement of thermomechanical recycling for polysynthetics
    - Cotton-2-biochar
    - Substitute fuels (RDF) from polysynthetics
    - Pretreatment of textile waste (extended sorting and shredding)

10 References

Ahiable, K., & Triki, C. (2021). *Tony Blair Institute for global change.* Retrieved from Tackling Ghana's Textile-Waste Challenge: https://www.institute.global/insights/climate-and-energy/tackling-ghanas-textile-waste-challenge

Bengtsson, J. P. (2022, 06 06). Chemical Recycling of a Textile Blend from Polyester and Viscose, Part II: Mechanism and Reactivity during Alkaline Hydrolysis of Textile Polyester. *Sustainability* .

Bianchi, S. B.-A.-T.-C.-B. (2023, 04 15). Opportunities and Limitations in Recycling Fossil Polymers from Textiles. *Macromol*, pp. 120-148.

Brivio, L., & Tollini, F. (2022). Towards Circular Economy: Closing the Loop with Chemical Recycling of Solid Plastic Waste. *Advances in Chemical Engineering*.

BVSE (Bundesverband Sekundärrohstoffe und Entsorgung), F. T. (2020). *Bedarf, Konsum und Wiederverwendung von bekleidung in Deutschland.*

Cay, A. Y. (2020, 04 01). Application of textile waste derived biochrs onto cotton fabric for improved performance and functional properties. *Journal of Cleaner Production*.

EEA. (2023). *EU exports of used textiles in Europe's circular economy.* Retrieved from ETC CE Report 2023/4: https://www.eea.europa.eu/publications/eu-exports-of-used-textiles

EEA. (2023, 01 27). *European Environment Agency*. Retrieved from https://www.eea.europa.eu/themes/waste/resource-efficiency/plastic-in-textiles-towards-a

EPA. (2018). Retrieved from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/textiles-material-specific-data

EuRIC. (2021, 02 02). *EuRIC.* Retrieved from https://euric.org/resource-hub/position-papers/euric-updated-position-on-epr-schemes-for-textiles

eur-lex.europa.eu. (2024, 01 10). Retrieved from https://eur-lex.europa.eu/EN/legal-content/summary/eu-waste-management-law.html

European Comission. (2023, 07 05). Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3635

Fashion for Good. (2022). Sorting for Circularity India: Wealth in Waste. https://reports.fashionforgood.com/report/sorting-for-circularity-india-wealth-in-waste/.

Flustix . (2022, 12 12). *flustix.com*. Retrieved from https://flustix.com/en/blog/german-start-up-invents-method-to-recycle-polyester-from-textiles/

Holcim Technology Ltd and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. (2020). *Production, Guidelines on Pre- and Co-processing of Waste in Cement.* Holcim Technology Ltd and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

hp-textiles. (2024). Retrieved from https://shop.hp-textiles.com/shop/en/Fillers-Additive/

Interview1. (2024, 01 04). (EB, Interviewer)

Interview2. (2024, 01 15). (EB, Interviewer)

Khandelwal, B. B. (2023, 05 31). *bcg.com*. Retrieved from https://www.bcg.com/publications/2023/end-of-life-recycling-in-the-fashion-industry

Lee, H. S.-Y. (2023, 01 10). Upcycling textile waste using pyrolysis process. *Science of the Total Environment*.

Lundberg, D., & Devoy, J. (2022, 09 22). *Boston University*. Retrieved from https://www.bu.edu/sph/news/articles/2022/the-aftermath-of-fast-fashion-how-discarded-clothes-impact-public-health-and-the-environment/

McKinsey. (2022). *Scaling textile recycling in Europe - turning waste into value.*

moldie.net. (2023, 12 19). Retrieved from https://moldie.net/compression-molding-vs-injection-molding/

Mortensen, L. (2023, 02 27). *EEA* . Retrieved from https://www.eea.europa.eu/en/newsroom/news/europes-used-textiles-are-an-increasing-waste-and-export-problem

Mower, J., Dembele, G., Strezelec, A., & Thapa, B. (2022, 08 25). Cotton waste-derived biochar and compost improve early growth and AMF association in cotton. *Agrosystems, Geosciences & Environment*.

OEC. (2021). *What does Ghana import? 2021*. Retrieved from https://oec.world/en/visualize/tree_map/hs17/import/gha/all/show/2021

Parmakoglu, E. Ü. (2023, 01 20). Valorization of Solid Wastes from Textile Industry as an Adsorbent Through Activated Carbon Production. *AATcc Journal of Research*.

Recycle Re_fashion. (2022). Retrieved from https://recycle.refashion.fr/en/cartographies-du-recyclage/

Reinkenhoff, A.-K., & Ahlmann, T. (2023). *Secondhand – Second Thoughts? Von Strukturen, Prozessen und Akteuren im globalen Alttextilhandel.* Dachverband Fairwertung e.V.

Schirmer, J. (2024, 01 11). *Statista*. Retrieved from https://de.statista.com/themen/8254/secondhand/#topicOverview

Textile Technology. (2022, 04 04). *textiletechonology.net*. Retrieved from https://www.textiletechnology.net/fibers/trendreports/ita-current-challenges-and-solutions-for-the-recycling-of-mixed-synthetic-textiles-31929

The EU Chemical Industry Transition Pathway. (2024). Retrieved from https://cefic.org/a-solution-provider-for-sustainability/chemical-recycling-making-plastics-circular/chemical-recycling-via-dissolution-to-plastic/

The OR Foundation. (2022). *Waste Makes Visible Our Separation From Nature: A Waste Landscape Report.* Retrieved from https://theor.org/wastelandscape

Tulashie, S. K. (2023, 08 24). Adsorptive removal of reactive violet 5 azodye (V5R) with biochar: An ecofriendly technology. *Sustainable Chemistry for the Environment*.

Umweltbundesamt (German Environmental Agency). (2019, 04 18). Retrieved from https://www.umweltbundesamt.de/alttextilien#hinweise-zum-recycling

umweltbundesamt.de. (2024, 01 10). Retrieved from https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management/waste-regulations

van Duijn, H., Papu Carrone, N., Bakowska, O., Huang, Q., Akerboom, M., Rademan, K., & Vellanki, D. (2022). *Sorting for Circularity Europe - An evaluation and commercial assessment of Textile Waste Across Europe.* Fashion For Good, Circle Economy.

Watson, D., Aare, A.-K., Trzepacz, S., & Dahl, C. (2018). *Used Textiles Collection in European Cities.* Retrieved from http://www.ecap.eu.com/wp-content/uploads/2018/07/ECAP-Textile-collection-in-European-cities_full-report_with-summary.pdf

Watson, D., Palm, D., Brix, L., Armstrup, M., Syversen, F., & Nielsen, R. (2016). *Exports of Nordic Used Textiles. Fate, benefits and impacts, Tema Nord No 558, Nordic Council of Ministers.* Retrieved from Watson, D., Palm, D., Brix, L., Armstrup, M., Syversen, F., Nielsen, R., 2016,: https://norden.diva-portal.org/smash/get/diva2:1057017/FULLTEXT03.pdf

www.trademap.org. (2024). Retrieved from https://www.trademap.org/Country_SelProductCountry_TS_Graph.aspx?nvpm=1%7c288%7c%7c%7c%7c6309%7c%7c%7c4%7c1%7c2%7c1%7c2%7c1%7c2%7c1%7c1%7c2

www.trademap.org. (2024, 01 20). Retrieved from www.trademap.org: https://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1%7c288%7c%7c%7c%7c6310%7c%7c%7c4%7c1%7c2%7c1%7c2%7c1%7c2%7c2%7c1%7c1

Zhang, D. (2010). 6 - Nonwovens for consumer and industrial wipes. In *Application of Nonwovens in Technical Textiles* (pp. 103-119). Woodhead Publishing Series in Textiles.