# From waste to worth

## Using technology and AI to drive sustainability and waste reduction in the fashion value chain

Roland Berger

# Management summary

**T**he fashion industry generates around 92 million metric tons of textile waste annually, with overproduction and poor inventory management leading to significant environmental damage.

In this report, we explore how technology, particularly artificial intelligence (AI), can drive waste reduction in the fashion industry. In the fashion industry, for example, AI applications in digital design, inventory management (including forecasting) and recycling show significant potential to reduce waste throughout product lifecycles.

Addressing waste is not only an environmental imperative but also a financial opportunity. By adopting AI-powered waste reduction strategies, companies can achieve sustainability goals, unlock cost savings and maintain competitiveness in a rapidly evolving market.

# Contents

# 1 Introduction

In a world where many economies are struggling, geopolitical tensions high and supply chains disrupted, companies are under intense pressure to grow revenues while ensuring cost competitiveness. However, pressure to do so in a sustainable way is also mounting, driven by regulation, investors, competitors and consumers. Stakeholders are also getting smarter about companies' sustainability claims, making it a field that companies need to prioritize and navigate carefully.

One key topic within sustainability that has been under focus is waste. This is an important area to address as reducing waste can generate significant cost savings while supporting sustainability goals in parallel. Waste may refer to waste generated throughout the product life cycle, from inputs manufacturing to end-of-life treatment, or the inefficient use of resources (e.g., water, energy, etc.) during the process. This report will focus on leveraging technology, and in particular artificial intelligence (AI), to drive out waste generated in the fashion industry. We have chosen fashion as this is an industry in consumer goods where we see the greatest potential to drive the sustainability and cost reduction agendas in parallel by reducing waste production throughout the value chain.

# 2 Importance of combating waste

Almost every step in the value chain, even after it reaches our door, generates waste. And waste has significant negative environmental, humanitarian and financial consequences.

Within **the fashion industry,** the prevalence of waste is equally staggering. Approximately 92 m metric tons of textile waste are generated annually across the world, and this figure is set to reach 148 m metric tons by 2030[1]. The increasingly prevalent trend of over-buying or over-consuming has contributed to overproduction. As a result, c. 30 % of clothes produced are never sold at full price and are marked down significantly or passed on to secondary sales channels[2]. Part of this overconsumption or over-buying can be attributed to the rise of social media and fast fashion, as retailers produce clothing that is trendy for a short period of time and encourage consumers to keep purchasing. Consequently, the average amount of clothing purchased by a consumer has risen by 60 % between 2000 and 2014[3]. Coupled with poor forecasting and inventory management, excess stock soon becomes a huge source of waste to contend with. Overproduction and disposal post-consumption also have environmental implications, both during the production process and after disposal. The clothing production process is highly resource-intensive and damaging to the environment: growing of materials such as cotton requires 10,000 liters of water to produce 1 kg of cotton[4]; dyeing and finishing fabrics generate 3 % of global $CO_2$ emissions and 20 % of global water pollution, while using large amounts of fossil-fuel-generated energy[5]. Furthermore, after use and disposal, only a limited amount of clothing is recycled. Taking the US as an example, 85 % of textiles thrown away end up in a landfill or are incinerated[6]. The rest are recycled in some form (e.g., used for stuffing, insulation, etc.[7]), but less than 1 % is used to make new clothing[8].

These statistics clearly demonstrate the severe economic, environmental and societal impacts of waste, creating impetus for companies to act. Many fashion companies have started making and acting toward sustainability and waste commitments. For example,

Nike has committed to diverting 100 % of waste from landfills in its extended supply chain, and recycling at least 80 % of waste into Nike products and other goods by 2025. It also aims to reduce the volume of fresh water used in textile dyeing and finishing by 25 % in the same period[9].

However, to effectively combat and reduce waste, companies must have a comprehensive understanding of how waste is generated in order to take effective steps to address it. (Over-consumption is a huge challenge, particularly in fashion, but is not in scope of this report.) Waste is generated mainly due to three reasons:

1. Inefficiencies in production, logistics and other processes, hence consuming excess resources and/or generating excess waste as a by-product
2. Challenges in planning and forecasting, which often lead to over-forecasting and hence over-production to meet consumers' demands and avoid out-of-stock
3. Lack of circular solutions when waste is generated, e.g., lack of recycling or repurposing of finished products at their end of life, especially in the case of fashion

While the "easy" solution would be to just "produce less," particularly to combat overproduction, this clashes with companies' financial interest to maximize sales. It also does not address the fundamental inefficiencies in processes that generate waste or use excess resources. Thus, there is a need to address these causes so that waste is minimized where possible throughout the value chain.

## 3 The road to reducing waste in the fashion value chain: Technology and artificial intelligence (AI)

Reducing waste throughout the value chain is a huge undertaking, but technology, particularly AI, has potential to help fashion companies on this journey. AI-driven technology has evolved greatly in the last decade, and there is now a multitude of applications that companies can use to drive out waste in the value chain, e.g., AI-powered demand forecasting, computer-vision-enabled textile waste detection and monitoring, etc.

This report will dive into each step of the fashion value chain, highlighting the key factors leading to waste generation, AI innovations and inspiring examples of what companies are doing to tackle waste.

By adopting solutions to tackle waste, fashion companies stand to achieve sustainability goals while unlocking financial savings. For example, a company with GBP 1 bn revenue in the fashion industry could achieve the following financial and environmental benefits by adopting waste reduction initiatives: ▶ A

## A  Example: Financial and environmental benefits through waste reduction initiatives

**For a GBP or EUR 1 bn fashion retailer**
4-5 % reduction in initial buying, and buying the right items, can give…

**GBP 30 m or EUR 35 m**
improvement in net profit

**2-8 %**
reduction in Scope 1-3 $CO_2$ emissions
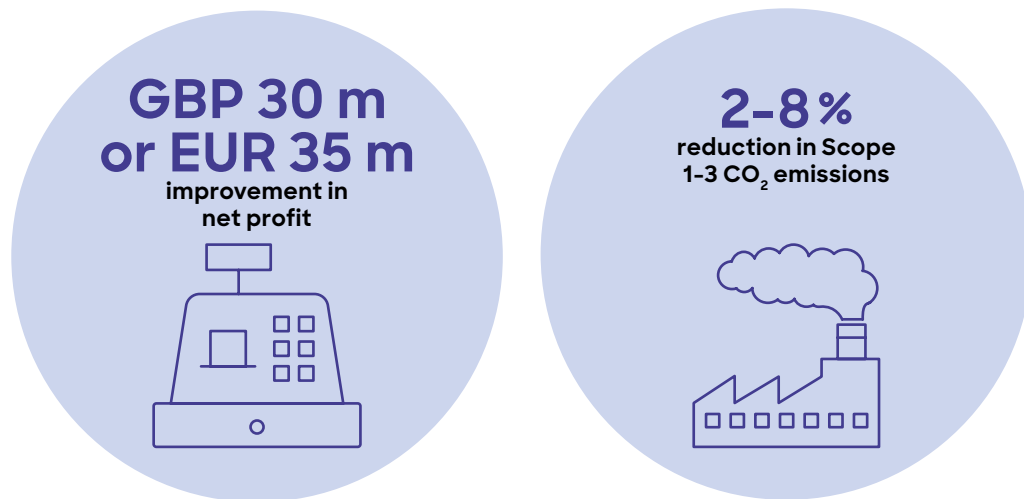
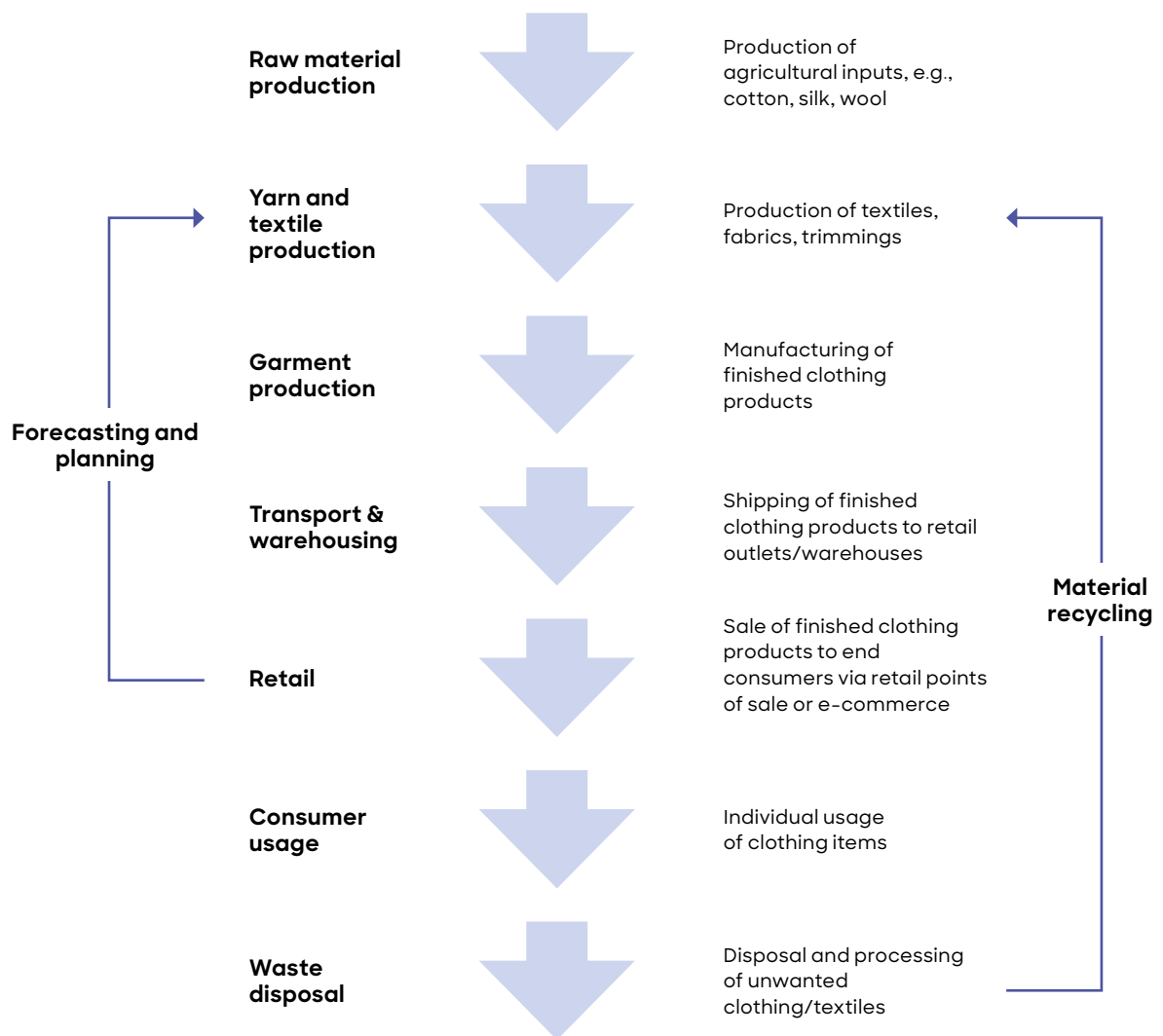Source: WRAP, WWF, secondary research, Roland Berger

The fashion value chain consists of various stages, from inputs production to disposal. There is a lot of in-built overproduction in the industry, due to the inherent difficulty of accurately forecasting what and how much to produce. Hence, there is a great need to improve planning processes to reduce the amount of waste generated and resources used. ▶ **B**

**Raw material to garment production**
A significant amount of waste in the fashion value chain starts upstream. It is estimated that upstream pre-consumer waste ranges from c. 15 % to 35 % of the materials used[10,11,12]. Furthermore, an estimated 47 % of all fibers in the fashion value chain become waste because of inefficiencies across various production stages[13].

This waste occurs due to several reasons. First, many clothing manufacturers already instill waste in the processes by ordering 3-10 % more materials than necessary to account for sampling processes, minimum order quantities and safety inventory. Second, producing textiles in large batches often results in inconsistencies in weaving, color and printing, parts of which are then disposed of. Third, even when trying to optimize fabric cutting for sewing finished garments, c. 15 % of fabric is often left behind in fabric scraps and offcuts[14,15]. Of the textiles left behind, yarn and cotton are the most common. This implies significant energy and resource wastage, as it takes 10,000 liters of water to make 1 kg of cotton[16], and a staggering 170,000 liters of water to make 1 kg of clean wool[17].

## B    Fashion value chain

| Stage | Description |
|---|---|
| **Raw material production** | Production of agricultural inputs, e.g., cotton, silk, wool |
| **Yarn and textile production** | Production of textiles, fabrics, trimmings |
| **Garment production** | Manufacturing of finished clothing products |
| **Transport & warehousing** | Shipping of finished clothing products to retail outlets/warehouses |
| **Retail** | Sale of finished clothing products to end consumers via retail points of sale or e-commerce |
| **Consumer usage** | Individual usage of clothing items |
| **Waste disposal** | Disposal and processing of unwanted clothing/textiles |

**Forecasting and planning**

**Material recycling**

Source: secondary research, Roland Berger

**Transport and warehousing to retail**

Fashion products are not perishable so most of the waste generated at these stages is packaging waste and waste of energy or resources during last-mile delivery. Energy usage for last-mile logistics is significant with the rise of e-commerce, and can lead to notable energy waste if routes and loads are not optimized.

It is also during the retail stage that stock waste becomes evident, either because of inaccurate forecasting processes or in-built excess stock (e.g., due to minimum order quantities). It is estimated that c. 10-40% of garments made every year are not sold or are significantly marked down[18]. Clothing returns is also a significant challenge to waste reduction, with return rates averaging at 30% in online and 10% in offline channels[19]. In Europe,

online return rates for clothing can even go up to 54% for dresses and 47% for skirts, based on 2022 Statista data[20]. In the UK, returns cost retailers GBP 7 billion and generate 750,000 metric tons of $CO_2$ emissions per year[21]. Returns also lead to clothing and resource waste, as returns have to undergo reverse logistics and complex reprocessing (e.g., cleaning, sanitisation, etc.) before being put back on shelf. Even then, 3% of returns are not resold[22], and subsequently have to be recycled or disposed of. However, the recycling process is usually costly and inefficient, leading many retailers to opt for disposal instead, usually through landfill or incineration or by passing on to a third party. Considering the resources that have been used to create these items, the implicit and explicit waste generated is significant.

**Consumer usage and disposal (including material recycling)**

Consumers today wear a piece of clothing seven to 10 times on average, which is 35% less than what they used to 15 years ago[22]. This can be attributed to various factors, including the rise of fast fashion, consumerism in the age of social media, etc., leading to rampant overconsumption. As a result, a huge amount of unwanted clothing is thrown away. For example, in the UK, more than 2 metric tons of clothing are bought every minute, but yet Britons throw away 300,000 metric tons of clothing every year into rubbish bins. Furthermore, a very small amount of this unwanted clothing is recycled, due to the cost and complexity of sorting, recycling and reprocessing mixed materials[23]. Europeans also spend a notable 4% of their total household expenditure on clothing and footwear, approximately EUR 490 per year. However, 4-9% of clothing on the market is destroyed before they are ever used, amounting to 260,000 to almost 600,000 tonnes a year[24,25].

## SOLUTIONS

Various solutions have been established to tackle fashion waste and reduce resources usage. In particular, many AI-backed solutions show promising potential and are starting to be adopted across the industry. An overview of the types of technologies being used are: ▶ C
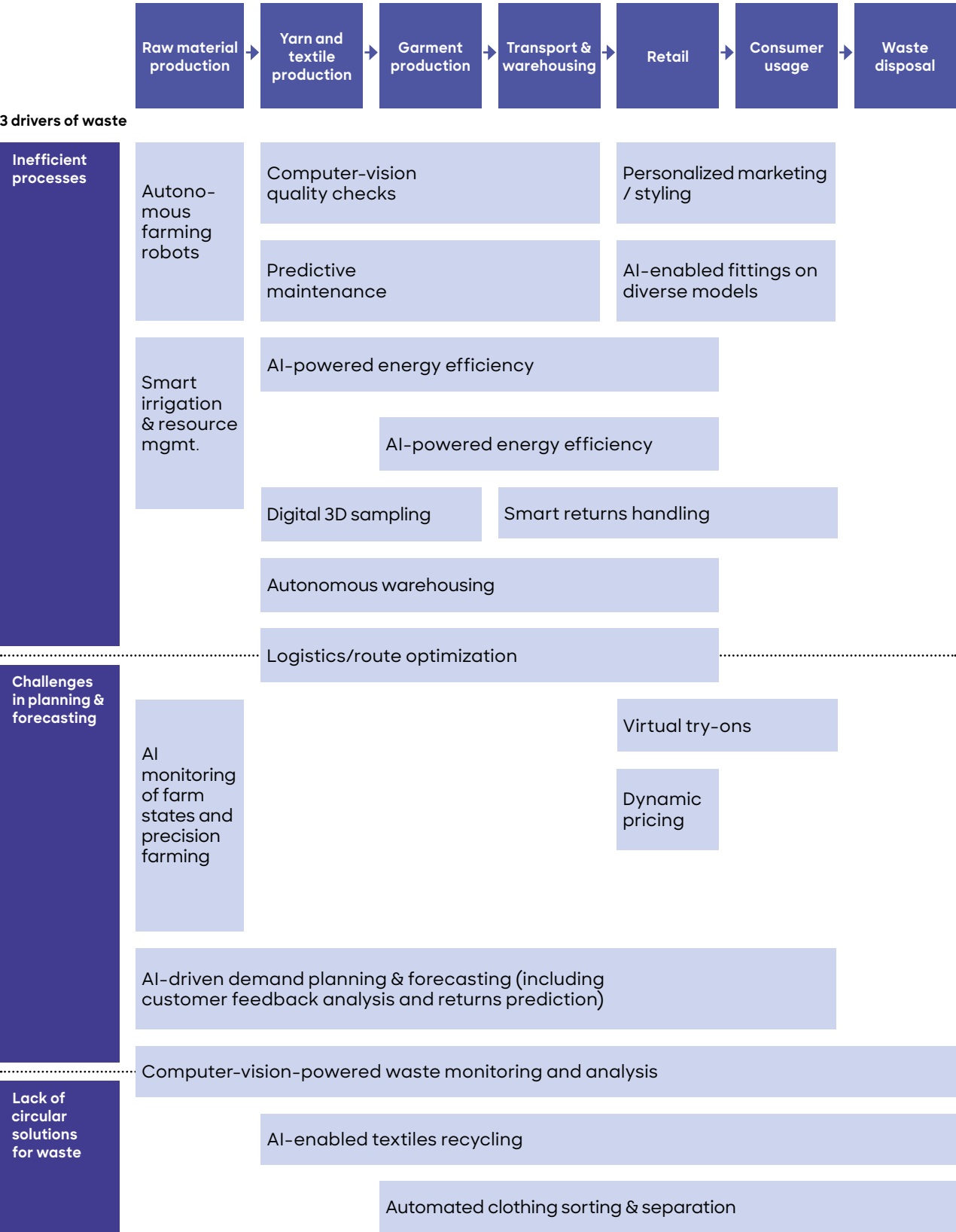
**Raw material to garment production**

Solutions to reduce fashion and textile waste exist throughout the fashion value chain. In addition to solutions that assist the agricultural aspect (e.g., precision farming in cotton agriculture), AI can also be used in digital design, sampling, inspection and inventory planning processes to reduce waste.

**Example 1:** The sampling process is a significant generator of textile waste, worth USD 6 to 8 billion each year. However, its waste can be optimized through 3D sampling processes. Brands typically receive four samples before the final product is made, but with 3D sampling, suppliers can create photorealistic renders of garments with fewer real samples. Optitex is an example of a 3D sampling solution that uses AI to support fabric simulations in the virtual environment[26]. It has reported that its software enables brands to reduce physical samples and product development timelines by 50%[27,28].

**Example 2:** Smartex AI, a Portuguese technology company, uses AI to empower factories working with textiles to produce with full traceability and zero waste. It produces computer-vision-powered hardware that can detect textile defects in real time, and also has a digital

## C    Technology use cases along the fashion value chain

| Raw material production | Yarn and textile production | Garment production | Transport & warehousing | Retail | Consumer usage | Waste disposal |
|---|---|---|---|---|---|---|

**3 drivers of waste**

### Inefficient processes

- Autonomous farming robots
- Computer-vision quality checks
- Personalized marketing / styling
- Predictive maintenance
- AI-enabled fittings on diverse models
- Smart irrigation & resource mgmt.
- AI-powered energy efficiency
- AI-powered energy efficiency
- Digital 3D sampling
- Smart returns handling
- Autonomous warehousing
- Logistics/route optimization

### Challenges in planning & forecasting

- AI monitoring of farm states and precision farming
- Virtual try-ons
- Dynamic pricing
- AI-driven demand planning & forecasting (including customer feedback analysis and returns prediction)

### Lack of circular solutions for waste

- Computer-vision-powered waste monitoring and analysis
- AI-enabled textiles recycling
- Automated clothing sorting & separation

Source: secondary research, Roland Berger

factory management platform where users are able to gain visibility over their textile operation[29]. Through early detection of defects, Smartex is able to minimize textile waste. Smartex estimated that it has been able to reduce fabric waste by 1 million kg since its founding in 2018 up until March 2024[30].

### Transport and warehousing to retail

Smart forecasting and inventory management can help retailers reduce waste from the start and reduce the need to overbuy. AI can take in a vast amount of data points and assist forecasting, planning and purchasing with higher accuracy. Resources used in transportation and warehousing can also be optimized and reduced.

**Example 1:** Heuritech is a technology-based market insights company that uses computer vision on a large number of fashion images to quantify what people are wearing globally and anticipate market shifts. Its algorithm analyzes more than 3 million social images a day and detects 2,000 fashion attributes. Heuritech's technology enables it to assist fashion clients such as New Balance and Dior to produce only what consumers want, thereby reducing unsold products and waste[31].

**Example 2:** RFID technology is becoming increasingly commonplace among retailers, with players such as Zara and Uniqlo[32] being well-known adopters. On a basic level, RFID allows retailers to identify and track multiple items simultaneously, and AI is being introduced to detect and correct errors in tracking data[33]. RFID adoption brings several benefits to retail operations, such as improved stock control and inventory visibility, which can help retailers make decisions about replenishment, markdowns, etc., to prevent overstocking and reduce waste.

**Example 3:** AI is being incorporated into last-mile delivery route optimization to make journeys more efficient. AI-powered GPS systems analyze factors such as past delivery routes, traffic, weather, order volume, etc., to determine the most efficient route that will save fuel and cut down on travel time and overall delivery costs[34]. Some solutions providers estimate that route optimization can reduce fuel usage by 10-30 %[35] due to reduced distance traveled and shorter waiting time in traffic.

### Consumption and disposal (including material recycling)

Consumers can leverage the support of AI when making purchasing decisions to reduce overbuying and overconsumption. There is also a need for innovation in clothing recycling processes to make recycling a more viable option for businesses.

**Example 1:** The fashion industry has historically faced challenges in model diversity, as photographing clothing on models of different shapes, ethnicities, ages, etc., for e-commerce is very costly. Veesual.ai uses its proprietary, AI-driven Image Generation Engine to deliver high-quality product imagery that can be adapted onto any model. With its Switch Model experience, shoppers can choose a model they identify with and Veesual.ai's algorithm will be able to "fit" the clothing onto the new model's body[36]. This helps shoppers to better visualize the clothing and potential ways to style it, which reduces the likelihood of returns and increases the probability of usage, therefore reducing waste.

**Example 2:** French company CETIA has introduced an AI-powered mechanical solution that can separate mixed materials in preparation for textile recycling. Its machine can rapidly sort clothes by color and composition and remove hard elements like zippers and buttons[37]. Separation is historically a laborious and hand-operated process, but CETIA's innovation demonstrates how the recycling process could become more automated and cost-efficient to facilitate recycling adoption, and thus reduce waste.

# 4 Conclusion

Evidently, waste in the fashion industry is a significant issue that needs to be tackled, not only for environmental reasons, but also because there are clear financial benefits for doing so: companies can not only reduce costs, but also be more competitive and stay relevant to consumers. While eradicating waste is a daunting task, there are a myriad of AI-powered solutions that can help companies get started. There will be much to do, from understanding the company's current sources of waste, to scoping out and implementing solutions. Roland Berger has significant experience in markdown reduction as well as process waste reduction and returns reduction for fashion clients. We are able to advise fashion companies on how to leverage AI and technology-based solutions to achieve impactful results.

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# Further reading

➜ *BLACK SWAN SCENARIOS AND IMPACTS ALONG THE FASHION VALUE CHAIN*

➜ *SUSTAINABLE FASHION - CHALLENGES, SOLUTIONS AND A PATH TO NET ZERO*

➜ *CONSUMER GOODS, RETAIL & AGRICULTURE*

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