

# **SUSTAINABILITY IN APPAREL INDUSTRY**

## **AN OVERVIEW & KEY TAKEAWAYS**

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# Executive summary

This e-book is a starting point for anyone curious about where clothes come from and what happens to them when we're done wearing them. It introduces core ideas and current innovations to academics, industry leaders, policymakers, entrepreneurs, and conscious consumers. The objective is to spark further inquiry and support informed decision-making, encouraging readers to explore these topics in more depth and contribute to building a more sustainable and regenerative future for fashion.

This e-book offers a comprehensive overview of the sustainability challenges and innovations across the apparel value chain. It highlights critical environmental and social issues, examines shifting consumer behavior, and introduces circular economy strategies that are gaining momentum across the industry.

Fashion today is fast, affordable, and widely accessible, but it comes with hidden costs. Most clothes are produced quickly and cheaply, worn a few times, and then discarded. Behind each piece lies a story of resource use and waste. This includes textile waste, water waste, and greenhouse gas emissions. Textile waste is generated at every stage of the linear production model. During fiber production, non-usable fibers are left behind. In manufacturing, fabric offcuts, defective garments, and overproduction contribute to material loss. Distribution and retail add to this through unsold inventory and returns. At the consumer level, clothing is often discarded after only a few wears, resulting in high volumes of post-consumer waste that typically end up in landfills or incinerators.

Water waste is another major issue. Large quantities are consumed and polluted during dyeing, finishing, and textile processing. During the use phase, washing and machine drying require more water and energy. Synthetic garments also shed microplastics during laundry, which enter waterways and contribute to marine pollution.

Emissions are an equally significant form of waste. The fashion industry is responsible for substantial greenhouse gas output due to energy-intensive manufacturing, long transportation chains, and short product life cycles. Global clothing consumption has also increased, while the average number of wears per item has decreased, especially in high-income regions. This drives up emissions tied to both production and disposal.

To address these issues, this e-book explores circular strategies such as resale, rental, repair, and recycling. These models aim to extend product life, reduce resource use, and lower emissions. Their effectiveness is evaluated using Life Cycle Assessment (LCA) and Social Life Cycle Assessment (SLCA), which measure environmental and social impacts across a product's life cycle. To ground these ideas in practice, we examine how companies like Rent the Runway and MUD Jeans are rethinking business models to extend product life and reduce waste.

A recurring theme explored in this e-book is the role of circularity at the intersection of technology, fashion, and sustainability. Technology serves as a powerful enabler of circular practices. Digital Product Passports can provide consumers with transparent product information, helping them make informed choices. Artificial intelligence is being applied to improve sorting processes in textile recycling. Meanwhile, digital platforms are supporting the growth of business models like rental and resale, which help extend product life and reduce overproduction.

To navigate this e-book, click on any underlined text to open a hyperlink and explore additional resources. Some images are linked to videos, so clicking on them will allow you to view related content and gain deeper insight into the topics discussed.

Listen to this podcast on [overview of sustainability in fashion](#), discussing challenges in the linear value chain and exploring solutions through circular models. You do not have to be in the fashion industry to care about these issues. If you wear clothes, you are part of the story.



# Chapter ONE

## Introduction

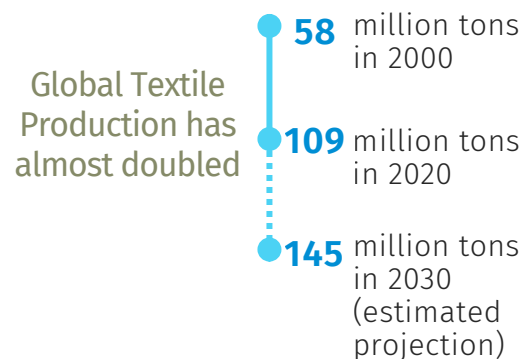
Clothing and fashion are part of everyday life and often reflect personal identity. Globally, clothing industry is worth \$1.3 trillion<sup>1</sup> and supports more than 300 million people across the value chain.

Today, most of the fashion system follows a linear model. This means clothes are made using large amounts of nonrenewable resources, worn for a short time, and then thrown away. Many end up in landfills or are burned, creating pollution and waste.

Fast fashion has transformed the way we shop by offering low-cost, quickly produced clothing. But this speed comes with a price. It often relies on poor labor conditions, low wages, and unsafe environments for workers. Because these clothes are not made to last, they are frequently discarded after only a few uses, adding to the growing problem of textile waste. This model puts pressure on people and the planet, making it unsustainable in the long run.

Globally, the fashion industry is the second largest consumer of water,<sup>2</sup> responsible for about 20% of industrial water pollution. It also contributes up to 35%, or 190,000 metric tons per year, of primary microplastic pollution in the oceans.

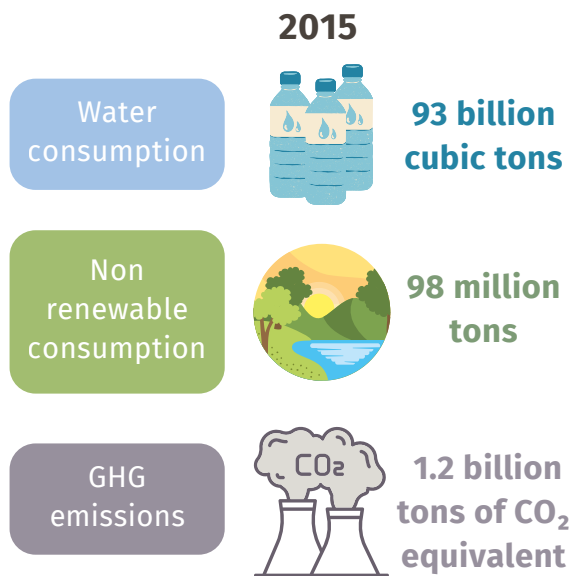
It is the second largest polluter after aviation industry and uses 98 million tons<sup>3</sup> of non-renewable resources and 93 billion cubic tons of water annually in the manufacturing process.



Source - EU's The impact of textile production and waste on the environment<sup>4</sup>

**In 2015, greenhouse gas emissions from clothing manufacturing reached 1.2 billion tons of CO<sub>2</sub>, exceeding the combined emissions from international flights and shipping.**

Illustration of the negative Impact  
of Fashion Industry



Source - Ellen MacArthur Foundation's A New Textiles Economy<sup>3</sup>

The fashion industry also causes social harm. Many workers face unsafe conditions due to exposure to toxic chemicals and poor factory safety. Tight deadlines and pressure to keep costs low often lead to long hours, low wages, and weak labor protections. While local communities may rely on these jobs, they also deal with the environmental damage that comes with them. For example, wastewater from textile production is sometimes released without treatment, polluting nearby rivers that people depend on for drinking, cooking, and fishing.

If the industry continues on its current path, textile production could consume over 25% of the global carbon budget needed to stay below the 2°C warming limit by 2050. Shifting away from the current linear and wasteful system is critical if we want to reduce harm and stay within our climate goals.

Visit [Youtube to watch the video](#) on how the Fashion Industry is destroying the Planet by Our Collective Impact

The current fashion system is built on a take-make-dispose model. It relies heavily on non-renewable resources to produce clothing that is often worn only a few times before being thrown away. Many of these garments end up in landfills or are incinerated. In fact, more than half of fast fashion items are discarded within a year of being made. This linear approach misses economic opportunities, puts pressure on natural resources, pollutes the environment, and contributes to both social and ecological harm.

The linear fashion system moves through five main stages: fiber extraction, manufacturing, distribution and logistics, consumption, and end of life. Each stage involves processes that use materials, water, energy, and chemicals. Along the way, they produce waste, release emissions, and create both environmental and social impacts.



Illustration of Linear Fast Fashion Process (adapted from Ellen MacArthur Foundation)

## Fiber Extraction

Raw fibers are sourced and processed during this stage. It includes transporting materials from extraction sites to yarn preparation facilities and spinning yarn from filament and staple fibers..

## Manufacturing

Yarn is knitted or woven into fabric, then prepared, dyed, and finished. The process also includes transporting fabric between stages and assembling final products through cutting and sewing.

## Distribution

This stage involves transporting finished apparel from manufacturing sites to retail stores, and then to end users.

## Consumption

This phase reflects how clothing is used and maintained, including washing, drying, ironing, and other care routines.

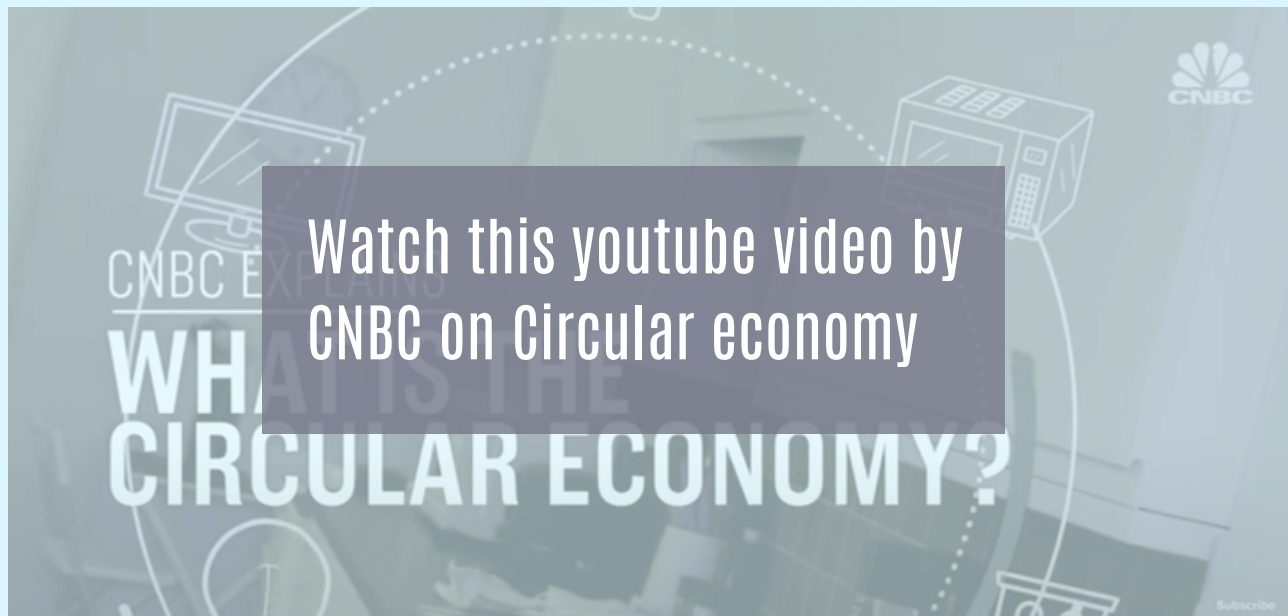
## End of Life

Garments are collected after use and transported to landfills or incineration facilities for final disposal.

Transitioning to a circular economy could unlock an economic opportunity worth USD 560 billion. Achieving this requires a deep understanding of the value chain and the development of new business models.

## Circular Economy

Circular economy shifts the fashion industry from a linear supply chain to one that is regenerative by design. In this system, materials are kept in use for as long as possible and never become waste by circulating them through processes such as maintenance, reuse, refurbishment, remanufacturing and recycling.



The circular economy approach, often referred to as "cradle to cradle," focuses on keeping materials in use for as long as possible. This includes recovering materials and energy, using closed-loop recycling systems, and supporting models like renting and sharing to extend the life of garments. It also aims to reduce resource use and make material inputs more efficient.

The goal is to move away from the current linear model and toward systems that regenerate resources and reduce waste.

This shift involves:

- Encouraging reuse and extending garment life through rental, resale, and swapping models
- Advancing recycling technologies to convert used textiles into new fibers
- Enforcing producer responsibility policies that make brands accountable for end-of-life garment disposal
- Improving supply chain sustainability by reducing water, energy, and chemical use in production

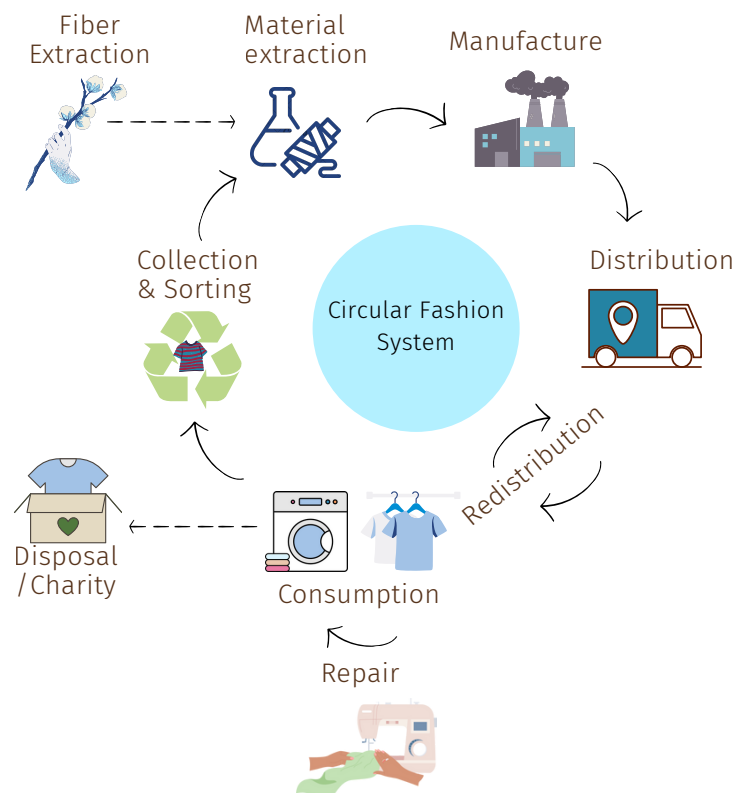


Illustration of Circular Fashion Process (adapted from Ellen MacArthur Foundation)

## Chapter TWO

# Fiber Extraction

Currently, three main types of raw materials are used in textile production: plant-based cellulosic fibers (cotton, linen, etc.) animal-based fibers (wool, silk, etc.), and synthetic or artificial fibers (nylon, polyester, etc.). Each has drawbacks that limit its suitability for a circular system.

Cellulose and protein-based fibers compete for agricultural land. As the global population grows, demand for both land and freshwater continues to rise. Cotton cultivation, for example, uses large amounts of water, fertilizers, and pesticides. These inputs are especially high unless regenerative farming methods are applied.

Wool also has a high land footprint, with estimates reaching up to 278 hectares needed to produce one ton of fiber. In comparison, cotton requires just over 1 hectare per ton. With farmland increasingly needed to grow food, scaling cotton or wool production could be difficult.

Textile production also uses approximately 43 million tons of chemicals each year. These include dyes and bleaches used in finishing processes, which contribute significantly to the industry's overall resource consumption.

**Polyester, a synthetic fiber, relies heavily on non-renewable resources and fossil fuels. Producing plastic-based fibers for textiles consumes an estimated 342 million barrels of oil each year.**

**It is estimated that cotton production involves 200,000 tons of pesticides and 8 million tons of fertilizers annually. Although cotton uses just 2.5% of the world's arable land, it accounts for 16% of global pesticide use. In India, half of all pesticides are used for cotton farming, which poses serious health risks for farmers.**

Illustration of the Impact of Raw Materials Used

### Fiber

Cotton

**200k tons pesticides**

Wool

**278 hectares of land per ton of fiber**

Polyester

**342M barrels of oil**

**Think about it:** Every material choice, whether natural or synthetic, involves trade-offs. Choosing the right fiber is about more than just how it looks or feels. It also means thinking about the long-term impact on land, water, and communities.

The move toward a more responsible fashion system starts with what clothes are made from. New materials have the potential to reshape how garments are produced, making them less harmful to the environment. Researchers and companies are now creating alternatives to traditional fibers that use fewer natural resources and create less waste.

Two promising innovations are Circulose and Galy's lab-grown cotton, both of which aim to shrink the industry's environmental impact by rethinking raw materials.

### Circulose

Circulose is a company leading the way in chemical textile recycling. It focuses on the end-of-life stage of clothing by turning old garments into a biodegradable alternative to new, virgin materials. This approach helps brands reduce their reliance on raw resources and supports a circular system where materials are reused instead of wasted.

Watch how Circulose is  
made on Youtube

CIRCULOSE®

Here's how it works:

- Used clothing and production scraps made from cotton and other high-cellulose materials are collected.
- These materials are sorted, stripped of non-textile parts like zippers and buttons, and shredded.
- After removing synthetic fibers like polyester, the remaining material is turned into a liquid pulp, then dried into sheets.
- These dried sheets are sent to fiber producers, who convert them into new fibers like viscose or lyocell.
- Brands such as H&M, Levi's, and Zara use these fibers in their sustainable collections.

By connecting textile recycling directly to new clothing production, Circulose helps close the loop in fashion. It's a real-world example of how innovation can support sustainability without sacrificing quality or style.

**The takeaway:** Every step forward in materials innovation brings us closer to a system where waste becomes a resource, not a burden. When we support or choose clothes made from recycled fibers, we help create demand for smarter, more sustainable solutions.

### Galy's Literally Cotton

Galy is a biotechnology company creating cotton through cellular agriculture. Its product, Literally Cotton, is grown from plant cells inside bioreactors, offering a sustainable alternative to traditional cotton farming. This method uses 99% less water and 97% less land than conventional cotton production, while reducing CO<sub>2</sub> emissions by 77%. It also avoids pesticides and insecticides, while enabling full traceability, transparency, and year-round production.

Solutions like Galy's show how science and innovation can help fashion reduce its impact, starting with how we make the raw materials.





## Other Innovations

A growing number of material innovations are helping the fashion industry reduce its reliance on virgin fibers and lower its environmental impact. These solutions focus on using waste as a resource and creating fibers with fewer inputs and emissions.

Companies like [Ambercycle](#), [Circ.Earth](#), [Econyl by Aquafil](#), [Evernu](#), [Repreve](#) focus on regenerating fibers from post-consumer waste, industrial textile scraps, and even ocean plastics. Their technologies turn discarded materials into high-quality yarns, reducing the need for new raw resources and keeping waste out of landfills.

Other innovations include [Bananatex](#), a durable, biodegradable fabric made from banana plants, [EcoVero by Lenzing](#), a lower-impact alternative to conventional viscose, and [Naia Renew by Eastman](#), which combines sustainably sourced wood pulp with recycled materials. All of these innovations support circularity at the fiber level by focusing on renewability, biodegradability, and efficient resource use.

## Want to go deeper?

Read the [Textile Exchange's Global fiber and materials market](#) report, for detailed data on global production, sustainability trends, and the shift toward preferred fibers, both natural and synthetic.

For insights on synthetic materials, see the [Textile Exchange's report on the Future of Synthetic fibers and materials](#). It highlights why reducing dependence on fossil-based fibers is essential. It also explores how recycled alternatives and better material choices can help fashion align with climate and biodiversity goals.

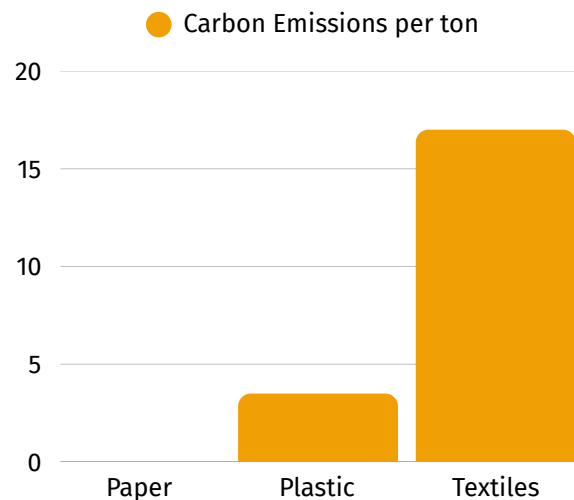
## Chapter THREE

# Manufacture

Textile production is a major source of global greenhouse gas emissions. In 2018, the industry released about 2.1 billion tons of green-house gas emissions<sup>5</sup>, which was more than the combined emissions from all international flights and maritime shipping. This level of impact is driven by the scale and inefficiencies of the current linear system, where garments are mass-produced with limited regard for environmental consequences.

Chemical use is another serious concern. The processes of dyeing, printing, and finishing fabrics involve large amounts of toxic substances. Each year, an estimated 280,000 tons of non-biodegradable dyes are released into the environment, either through treatment systems that cannot fully filter them or directly into rivers and lakes.

A striking example is the Citarum River in Indonesia, one of the most polluted rivers in the world. More than 2000 textile factories operate along its banks, and many discharge untreated wastewater into the river. This pollution alters the river's color and damages aquatic life. Local communities that depend on the river for drinking, bathing, and fishing face serious health problems, including skin conditions and respiratory issues, from prolonged exposure to toxic water.



Producing one ton of textiles generates approximately 17 tons of green-house gas emissions. In comparison, plastic production emits around 3.5 tons, while paper produces less than 1 ton per ton of material.

Textile dyeing is the second-largest source of water pollution globally. Wastewater from the dyeing process is often discharged into ditches, streams, or rivers without proper treatment.

Source - [World Economic Forum 2020<sup>6</sup>](#)

In response to growing environmental and social challenges, many fashion brands and manufacturers are working to improve how clothing is made. One key area of progress is automation.

Traditional garment production is labor-intensive. It involves separate steps for cutting, sewing, and finishing, which can make the process slower, more wasteful, and harder to control for quality. Automation brings these steps together into a streamlined, machine-driven system. This improves precision, reduces defects, and cuts down on wasted fabric.

Automation also supports environmental goals. For example, digital printing uses far less water and chemicals than conventional dyeing. Automated cutting systems help optimize how fabric is used, leaving behind fewer scraps. By making production more efficient, automation helps lower emissions and reduce water, energy, and chemical use.

Below are some examples of innovative processes that can be applied in dyeing and manufacturing:

### Suprauno

Suprauno is a sustainable, waterless dyeing and finishing technology that uses supercritical carbon dioxide (CO<sub>2</sub>) as the dyeing medium instead of water. This allows conventional dyes to be applied to a wide range of natural and synthetic textiles. Think of it like applying dye with pressurized CO<sub>2</sub>, similar to how dry cleaning works.

This offers several environmental benefits:

- **Water Conservation:** The process uses no water, solving one of the fashion industry's biggest sustainability challenges
- **Chemical Reduction:** It uses up to 90% fewer added chemicals, reducing the release of harmful substances
- **Energy Efficiency:** It lowers energy consumption by approximately 67%, helping to reduce the overall carbon footprint.

## CircularKnit

CircularKnit is a closed-loop manufacturing system that aims to eliminate material waste. Instead of cutting fabric from large rolls and stitching pieces together, garments are knitted directly from yarn into their final shape. This means there is no leftover fabric to discard, allowing production with zero textile waste.



## Unspun

Unspun is a sustainable fashion startup based in San Francisco that is rethinking how clothes are made. The company uses 3D body scanning and automated manufacturing to create custom-fit garments for each customer. The company's goal is to reduce fashion waste by eliminating overproduction and unsold inventory through on-demand production.



Using its proprietary 3D body scanning technology, Unspun creates a detailed digital model of each customer's body. This data is then used to make custom-fit garments through an automated process that skips several traditional manufacturing steps.

To do this, Unspun uses 3D weaving technology, which interlaces around 3,000 yarns at once to create seamless fabric structures. This allows for garments with fewer seams, such as pants without side seams or shirts without circular seams. The result is less fabric waste and improved comfort.

When paired with technologies like Suprauno's waterless dyeing and CircularKnit's zero-waste garment construction, Unspun's approach highlights how innovation can help reduce the environmental footprint of clothing production. These solutions lower water use, chemical discharge, and emissions while supporting more circular ways of making clothes.

## Chapter FOUR

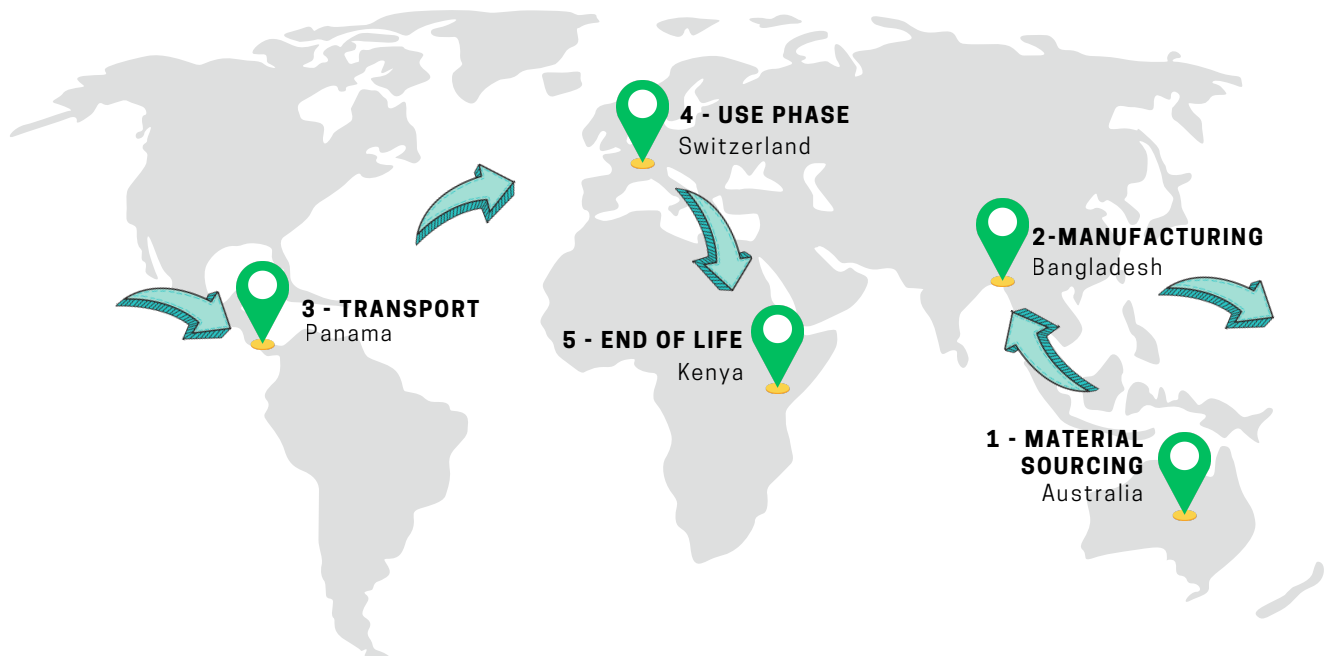
# Distribution

Managing the fashion supply chain is about more than just getting products delivered on time. It involves understanding what customers want, where they want it, and when they expect it. To meet these needs, brands must accurately predict demand and coordinate every part of the process. This includes design, manufacturing, logistics, and retail operations to ensure the right products are available in the right place, at the right time, and at the right price. An effective supply chain must balance cost, speed, and flexibility while also responding to increasing concerns about environmental impact and ethical labor practices.

To meet global demand, most fashion brands rely on complex supply chains that involve long-distance transportation.

The fashion supply chain is typically divided into five main stages: sourcing, manufacturing, transport, use, and end of life. From sourcing raw materials to delivering finished products, the use of air freight and shipping adds significantly to carbon emissions.

Illustration of a Global Supply Chain



Each stage of the fashion supply chain involves a wide range of stakeholders. For example, material sourcing includes cotton farmers, chemical suppliers, spinners, and fabric mills. Manufacturing involves dye houses, assembly lines, finishing units, packaging vendors, and quality inspectors. The transport stage brings in logistics providers, freight forwarders, and customs agents. The use phase is shaped by consumers and service providers like laundries or tailors. Finally, end-of-life processing involves waste collectors, sorters, exporters, recyclers, and landfill or incineration operators.

The journey from raw material to retail can take anywhere from six months to a full year. Even after the product is sold, its environmental impact continues through washing, wearing, and final disposal. These later stages extend the footprint of the garment far beyond the factory floor.

**A single garment may pass through 15 to 20 different hands before it is discarded. Each handoff brings differences in standards, oversight, and environmental practices. This level of complexity makes it challenging to manage sustainability, especially when sourcing and production happen across several countries with different rules, enforcement levels, and working conditions.**

One of the biggest roadblocks to sustainable transformation is the lack of traceability. Most brands work directly with their tier-one suppliers, such as garment factories. The earlier stages of production, including fiber sourcing, dyeing, and finishing, are often outsourced to subcontractors. As a result, brands have limited visibility into the environmental and labor conditions involved in making their products.

**Material production, preparation, and processing account for nearly 70% of the industry's total emissions and should be a primary focus for sustainability efforts.**

**The distance a garment travels is also significant. On average, it moves between 20,000 and 40,000 kilometers during its life. This includes travel from cotton farms or petrochemical plants to yarn mills, fabric processors, sewing factories, distribution centers, retailers, and finally to the consumer.**

This is where technology-enabled supply chains can make a big difference. Tools like RFID tags, QR codes, and blockchain platforms help trace raw materials from their source all the way to the final product. These tools also help verify whether suppliers are meeting social and environmental standards. By increasing visibility, technology makes it easier for brands to monitor their supply chains and support more ethical sourcing.

Reducing emissions in the apparel sector requires close collaboration with manufacturers and upstream suppliers. By improving coordination and transparency, digital tools also help strengthen ethical sourcing.

Technology plays a key role in building fashion supply chains that are more efficient and responsible. It improves forecasting, inventory management, and production planning, which are essential for reducing waste and producing only what is needed. One approach in operations is lean manufacturing. This method focuses on increasing efficiency by producing the right products, in the right quantity, at the right time. The goal is to eliminate excess inventory, reduce waste, and respond accurately to customer demand. For lean manufacturing to succeed, production must align with actual demand. Traditional fashion supply chains often depend on bulk manufacturing and long lead times, which result in excess inventory and heavy discounting. With tools like real-time planning, predictive analytics, and flexible manufacturing systems, brands can shift to smaller, more targeted production runs. When production closely matches actual demand, it becomes easier to avoid overproduction, shorten lead times, reduce material waste, and improve responsiveness to changing market trends.

Technology also improves visibility into supplier practices. When behavior across the supply chain becomes more transparent, it is easier to monitor working conditions, track environmental performance, and hold partners accountable. These advances help lay the foundation for more ethical sourcing and support a shift toward circular fashion models. With continued innovation and adoption, technology can help the fashion industry build supply chains that are more resilient, responsive, and sustainable.

While ethical sourcing and lean manufacturing show strong potential, their success depends on more than digital tools. Ethical sourcing requires constant monitoring of labor conditions, factory safety, and environmental impact across all supplier levels. Many brands still have limited insight beyond their direct suppliers, which makes it hard to trace raw materials or verify working conditions further upstream. Tools such as blockchain and QR labels, can help bridge this gap. These collect and verify data throughout the supply chain, offering a clearer picture of where materials come from and how workers are treated.



Some companies are exploring nearshoring, which means moving production closer to consumer markets. The goal is to shorten delivery times and reduce emissions from long-distance transportation. While this approach can offer some environmental benefits, it is not always practical or sustainable. Many nearby regions lack strong supplier networks, skilled labor, or easy access to raw materials. In addition, labor costs, tariffs, and logistics expenses can still be high, which limits the advantages of nearshoring.

**One growing opportunity for apparel brands is nearshoring, which involves moving production closer to consumer markets. Shorter supply chains can reduce emissions and minimize waste, helping brands meet new sustainability regulations and responding more quickly to changing demand.**

Relocating production does not always lead to better environmental outcomes. Processes like dyeing and finishing use a lot of energy and water. If the new location lacks access to renewable energy or proper wastewater treatment, emissions and pollution may increase rather than decrease. Social impacts also need to be considered. Moving production out of countries like Bangladesh or Pakistan may reduce environmental pressure in the short term, but it can also lead to job loss and economic disruption in those regions.

A more effective approach is to improve supply chains from within. Instead of shifting operations, brands can focus on building long-term relationships with suppliers, supporting factory upgrades, and increasing visibility across all tiers of production. Ethical sourcing becomes more meaningful when it includes supplier engagement, financial support, and clear expectations around labor and environmental standards. Lean manufacturing works best when brands and suppliers coordinate closely to align production with real demand, helping reduce waste and avoid overproduction. Improving existing systems offers a more reliable path to sustainable production than simply moving operations elsewhere without solving the underlying problems.

Patagonia works closely with its suppliers to support fair labor and strong environmental practices. Instead of relocating its production, Patagonia invests in the factories it already works with. This includes providing training, long-term contracts, and financial support to help suppliers meet high standards. The result is a supply chain that reduces waste, improves working conditions, and builds lasting partnerships based on trust and shared goals.



## Traceability and Transparency

Improving traceability in the fashion supply chain is key to building a circular system. When brands, manufacturers, and recyclers have clear and reliable information about materials, it becomes easier to recover and reuse textiles at the end of their life.

One important step is the use of digital product passports and clear material labeling. By integrating technologies such as RFID with Digital IDs, into garments during manufacturing, brands can store useful details like fiber content, dyeing methods, and finishing treatments. This information helps recyclers sort materials more efficiently and increases the chances that textiles can be reused instead of being discarded.

Several new solutions are helping improve transparency and support circular fashion systems. Applied DNA Sciences has developed CertainT, a bio-based marker used to track cotton throughout the value chain. When combined with blockchain technology, this system provides reliable data on material origin and composition, helping verify sourcing claims and build trust.

New platforms are also supporting infrastructure for circularity. SuperCircle, for example, is developing trackable garment collection and processing systems that streamline logistics and improve recycling outcomes. Similarly, the Fashion Positive's PLUS program brings together brands, designers, and suppliers to co-create solutions and identify high-volume materials in need of redesign for circular use. Industry-wide standards and partnerships are helping to scale these efforts. The Global Recycled Standard ensures consistency in recycled material claims, while platforms like Circle Economy's CircleMarket connect recyclers, textile mills, and brands to better match material supply with demand.

Some major brands, including Zara and H&M, have launched clothing take-back programs to support used garment collection. However, the actual impact of these efforts remains unclear. Investigations have found that many collected items are not recycled as claimed. Instead, a large number are exported to other countries, where much of the clothing ends up in landfills or open dumps.

Only 19% of major fashion brands are able to fully trace the sources of raw materials used in all key fabrics. This limited visibility creates challenges for accountability, sustainability, and informed decision-making across the supply chain.

Source - Fashion Transparency Index 2023 by Fashion Revolution<sup>7</sup>

## E-Commerce Growth and Rising Returns

The COVID-19 pandemic in 2019 and the lockdowns that followed caused a major shift in how people shop. With many physical stores closed or restricted, consumers turned to online platforms to buy clothes and other products. As e-commerce grew quickly, so did the volume of apparel returns.

One major reason is a shopping habit called bracketing, where customers buy the same item in multiple sizes or styles and return the ones that do not fit or meet expectations.

Returns typically fall into three categories:

- Mistaken orders or misleading product information
- Product issues, such as incorrect sizing, poor quality, or late delivery
- Abuse of return policies, including wardrobing (buying with the intent to use and return), bracketing (ordering multiple variations to try at home), and fraudulent claims

This growing problem creates major logistical challenges for retailers. Every return adds extra steps, including shipping, inspection, repackaging, and restocking. These steps increase costs and slow down operations. In response, many retailers are updating their return policies. Some are adding restocking fees or shortening the return window to help reduce unnecessary returns.

The problem is not only financial. Many returned items cannot be resold and end up discarded. This adds to landfill waste and increases the environmental impact of fashion. It also points to larger inefficiencies in how clothes are produced, sold, and delivered.

**Processing returns quickly is essential, especially in fashion, where trends change rapidly. If a returned item takes 30 to 45 days to reach shelves again, it may no longer be suitable for full-price sale.**

**According to the National Retail Federation, U.S. consumers returned more than \$816 billion worth of merchandise in 2022.**

Source - [Business Insider](#), December 2022<sup>8</sup>

**A decline in product quality has also contributed to higher return rates, indicating that improving clothing standards could help reduce the volume of returns.**

To address the growing challenge of returns, companies are implementing policies to reduce return rates and encouraging more sustainable behaviors. These efforts aim to lower costs and reduce the environmental impact of reverse logistics.

Some of the key strategies include:

- Encouraging exchanges instead of refunds - Companies like Happy Returns partner with brands to promote exchanges over refunds. For instance, customers may receive an additional \$10 in store credit if they choose to exchange an item rather than return it for a refund.
- Tiered loyalty perks - Some brands offer free returns as a benefit for loyal customers. For example, PrettyLittleThing (PLT) removed its £1.99 return fee for members of its paid loyalty program, while non-members still pay the fee. This approach supports return flexibility while discouraging one-time or impulsive purchases.
- Reframing return fees - Instead of calling return charges penalties, some brands now refer to them as "environmental fees." For instance, ASOS introduced a £3.95 "fair use" return fee for frequent returners, unless they keep at least £40 worth of items from their order, framing the charge as a way to promote responsible shopping.
- Drop-off return networks - Happy Returns also operates a network of physical drop-off points. Customers can return items without needing boxes or printed labels. These items are then bundled together and shipped in bulk, which reduces packaging waste and cuts down on transportation emissions.

Each year, around 5 billion pounds of returned goods end up in U.S. landfills. This results in approximately 15 million metric tons of CO<sub>2</sub> emissions, which is comparable to the amount of waste generated by 5 million people in a year.

Source - Optoro

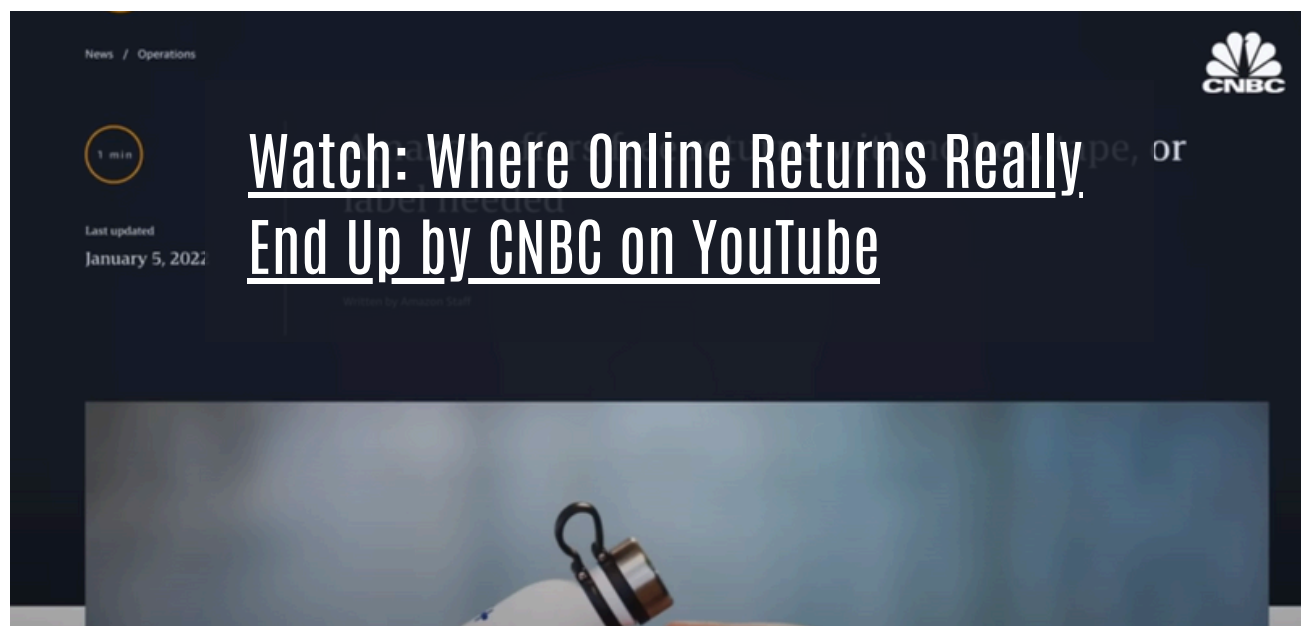
Some retailers, including Amazon, Walmart, and Target, have adopted returnless refund policies for select products as a way to reduce costs. In these cases, customers receive a refund but do not need to send the item back. This approach is used when returning the product would cost more than it is worth. For example, if it would cost \$30 to process the return of a \$20 T-shirt, the retailer may choose to refund the money and allow the customer to keep or donate the item.

These decisions are guided by internal systems that analyze item value, shipping costs, and the customer's return history. Returnless refunds are most often used for low-cost, bulky, or single-use items that are difficult to resell.

This model offers benefits for both customers and retailers. It simplifies the return process and reduces shipping, packaging, and emissions tied to reverse logistics. By avoiding unnecessary transportation and handling, companies can reduce waste and lower their environmental impact.

While returnless refunds are not suitable for every product, they are becoming more common in e-commerce as brands look for ways to improve customer experience, cut costs, and meet sustainability goals.

Listen to this podcast on Clotheshorse [about E-Commerce Returns](#).



## Chapter FIVE

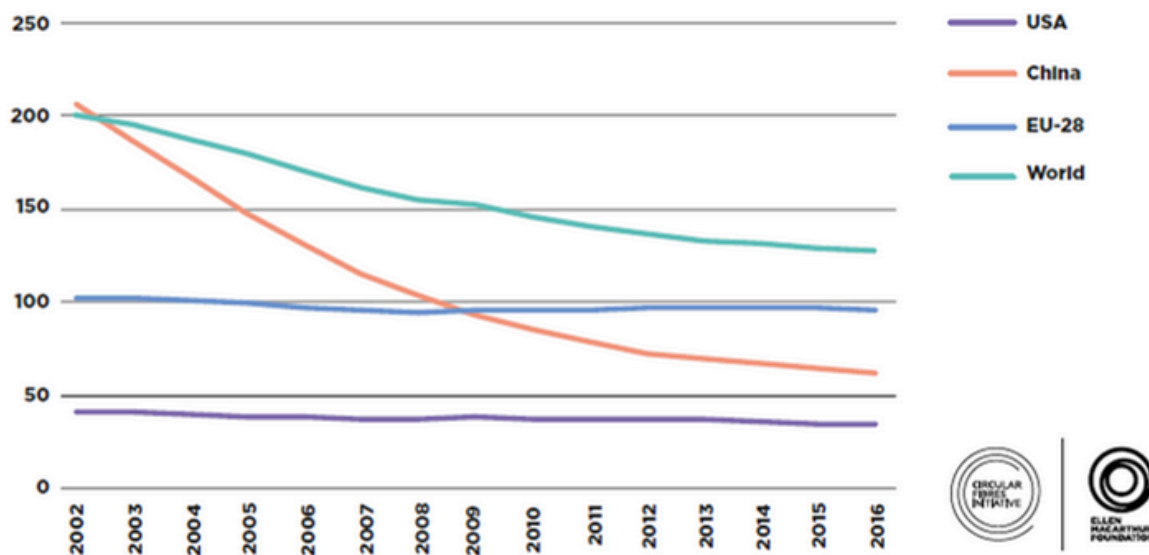
# Consumption

The quicker turnaround of new styles and the rise in the number of seasonal collections at affordable prices have encouraged consumers to buy more frequently. Globally, garments are now worn an average of only seven to ten times before being thrown away.

The rate of clothing utilization varies by region. Low-income countries tend to have higher usage per garment, while emerging and developed countries see significantly lower rates of wear before disposal.

Over the past 15 years, clothing production and manufacturing have doubled, largely due to the growth of fast fashion. This shift has contributed to a 36% decline in the average number of times a garment is worn before being discarded.

Figure - Average number of Times a new garment is worn (including reuse within each region)



Source - A NEW TEXTILES ECONOMY: REDESIGNING FASHION'S FUTURE BY ELLEN MACARTHUR FOUNDATION

For example, a study by the Hot or Cool Institute<sup>9</sup> found that average wardrobe sizes in India and Indonesia are significantly smaller than those in the United States or the United Kingdom, and clothes are used more intensively. However, this pattern is beginning to shift. As incomes rise and middle-class populations grow, there is a trend toward faster consumption and declining garment use, particularly in urban areas where Western-style shopping habits are becoming more common.

In contrast, in Europe and North America, the key challenge lies in increasing clothing utilization and shifting away from the perception of clothing as disposable.

The affordability of fast fashion has come at a cost. Lower prices often mean lower quality, leading to garments that wear out quickly and are replaced frequently. Durability is frequently overlooked in favor of style or price, and items are discarded once they lose their shape or appeal.

Encouraging the purchase of high-quality, longer-lasting garments can help shift this pattern. By choosing durable pieces, consumers can extend the life of their wardrobes, save money over time, and reduce their overall environmental footprint.

**In China, the average number of times a garment is worn has dropped from over 200 wears to just 62, which is lower than the average in Europe.**

**Globally, the value of clothing discarded each year is estimated at around USD 460 million. More than half of fast fashion are thrown away within one year of purchase, and this continues to grow annually.**



Watch: Why are all our clothes worse now on YouTube

Consumers play a vital role in shaping the environmental impact of fashion. Even garments made with the most sustainable practices require energy and resources for manufacturing and transportation. However, how long we use our clothes has a major influence on their overall footprint.

For example, extending the life of a garment by nine months, where the item is worn frequently over that period, can reduce its carbon footprint by 20 to 30%<sup>10</sup>. This reduction comes from avoiding the need to produce a replacement garment, which would otherwise require additional resources, energy, and transportation.

Despite this, current consumption habits are moving in the opposite direction. Instead of buying new items, consumers can adopt more sustainable alternatives, such as:

- Renting clothing for one-time needs, such as maternity wear, party outfits, or formal events
- Choosing second-hand clothing, which extends the life of garments and reduces demand for new production
- Reselling clothing on second-hand platforms
- Repairing worn garments instead of replacing them
- Sharing or donating items to friends, family, or local charities
- Returning used items through verified brand take-back programs

These small choices collectively lower fashion's environmental impact and keep clothing in use for longer. By extending the life of garments and minimizing unnecessary purchases, consumers can reduce pressure on resources, landfills, and production systems.

## Rental & Resale

One promising approach is the "sharing economy," also known as collaborative consumption. This model shifts away from ownership-based consumption and encourages people to rent, trade, swap, or borrow clothing. By coordinating the use of garments across multiple users, collaborative consumption helps extend the useful life of each item and reduces the demand for new production.

Today, people purchase nearly ten times more clothing than they did in the 1960s and 1970s. This rise in excessive consumerism has shortened the lifespan of garments and increased the environmental cost of fashion.

Reuse models such as rental and resale offer several benefits. They provide access to clothing at a lower cost than buying new and increase garment utilization, where each item is worn more throughout its life.

**The secondhand market is expected to reach \$70 billion by 2027.**

Buying a used piece of clothing is estimated to reduce its carbon footprint by over 70%<sup>11</sup>. This is especially impactful since most of a garment's environmental burden comes during the manufacturing stage, where water use, energy consumption, and chemical application are highest.

Researchers from Berlin's Hot or Cool Institute found that to meet the Paris Agreement goal of limiting global warming to 2.7 degrees Fahrenheit, individuals should purchase no more than five new garments per year. In contrast, the average U.S. consumer currently buys around 53 new clothing items annually. This wide gap highlights the need for more sustainable consumption habits and alternative ways of engaging with fashion.

Source - [Resizing Fashion for a Fair Consumption Space Report](#)



Both resale and rental models help extend the life of garments and reduce the need for new production. When brands manage these models directly through their own websites, they have a strong incentive to design durable, high-quality clothing.

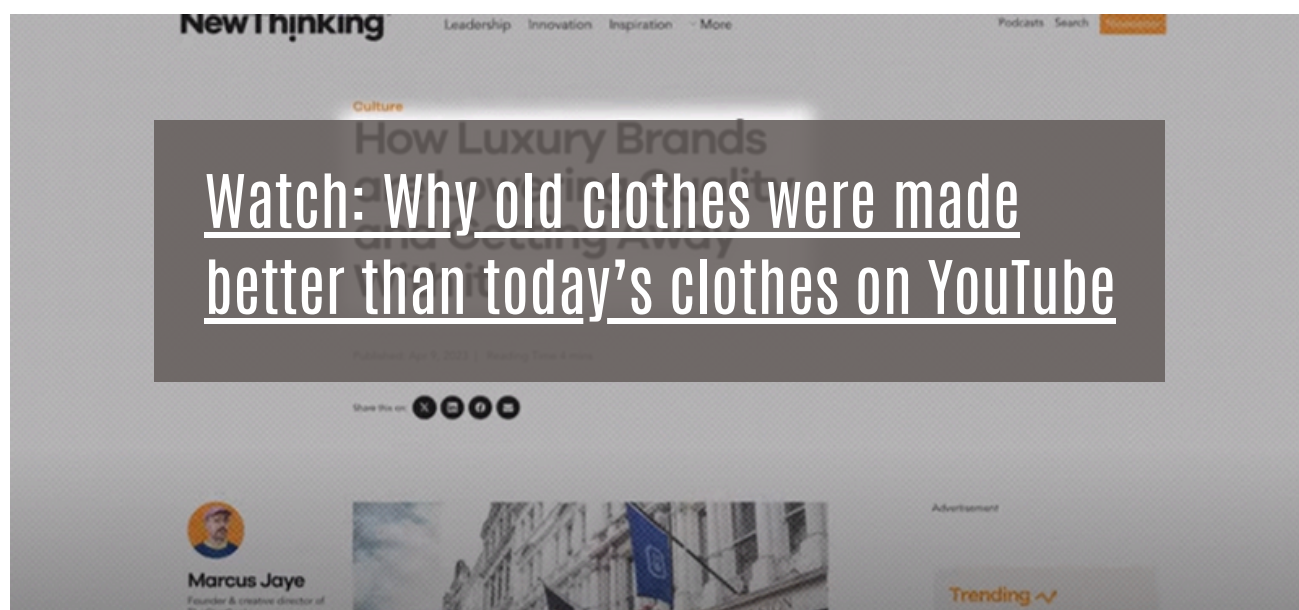


Well-made garments retain value, reduce returns, and perform better across multiple owners or users. Brands like [Free People](#) offer rental services, while others like [Patagonia](#), [Cotopaxi](#) and [Eileen Fisher](#) have introduced in-house resale programs. In both cases, durability supports profitability by lowering repair and replacement costs and increasing the number of times each item can be used. Third-party platforms such as Rent the Runway and Armoire also support this shift by offering access to a wide range of brands through subscriptions or one-time rentals. These models cater to different customer needs, such as:

- Subscription rentals for individuals who like to frequently update their wardrobe
- Size change rentals for people whose clothing no longer fits
- Occasional wear rentals for special events or activities, allowing access to variety without long-term ownership

While resale is growing rapidly in Western markets, adoption in parts of Asia faces several challenges. Many consumers have concerns about the quality and hygiene of secondhand items. These perceptions are further affected by the large-scale import of lower-quality used clothing from Western countries, which has contributed to negative attitudes toward resale. Explore this article and the accompanying video by ThinkChina on [the cultural perceptions that influence resale adoption in Asia](#).

Meanwhile, countries with high levels of fashion consumption such as the United States and Australia contribute significantly to global textile waste, both in the volume of garments purchased and the rate at which they are discarded. Shifting consumer behavior in these regions could have a meaningful impact on global emissions and resource use.



Resale and rental models present an opportunity to decouple fashion from disposability. When paired with product design, transparency, and consumer education, they offer a scalable path towards a circular and responsible fashion system.

### Rent the Runway (RTR)

Rent the Runway (RTR) was founded in 2009 by Jennifer Hyman and Jennifer Fleiss to allow women to rent designer dresses for special occasions instead of buying them. What began as a service for special occasions has grown into a subscription-based model that includes everyday wear, maternity, and workwear. RTR encourages consumers to adopt more circular and mindful wardrobe habits. The company operates within the growing global online clothing rental market, which was valued at \$1.24 billion in 2019 and is projected to reach \$2.92 billion by 2027. Through its rental services, RTR helps reduce the environmental impact of fashion by limiting the need for new production.

RTR manages an inventory of over 18,000 styles from more than 750 designer brands. Its operations are built for speed and efficiency, with returned items inspected, cleaned, and prepared for the next rental within 24 hours.

This fast-paced process is supported by one of the most advanced reverse logistics systems in the fashion industry. Unlike traditional retail logistics, which follow a one-way path from warehouse to customer, RTR's system is built around a circular flow. Each garment is tracked through its entire journey, including delivery, return, inspection, cleaning, maintenance, and re-distribution. The system continuously monitors inventory levels and customer demand, prioritizing which items to process based on real-time data. This allows RTR to minimize delays and maximize garment usage. To support these operations, RTR developed a patented logistics system tailored specifically to rental needs.

Since 2010, RTR estimates it has displaced the manufacturing of 1.6 million new garments. This has led to the conservation of approximately 67 million gallons of water, a reduction of 44.2 million pounds of CO<sub>2</sub> emissions, and savings of 98.6 million kilowatt-hours of energy.

In fiscal year 2023 alone, RTR displaced 154,623 garments, recycled more than 250 tons of plastic, and sourced 100% renewable energy for its key facilities.

The platform dynamically assigns tasks to ensure the most popular items are ready for the next customer quickly, while also managing garment care and repair when needed. By optimizing reuse cycles and reducing downtime between rentals, RTR increases the value of each garment and reduces environmental impact. RTR's model also extends to packaging and distribution. The company reuses shipping materials and consolidates deliveries whenever possible to cut emissions.

While RTR and similar platforms like Nuuly own and manage centralized inventories, new business models are emerging. One example is Pickle, a peer-to-peer rental platform that acts as a marketplace where individuals rent clothing directly to each other. This approach offers a more decentralized alternative, extending the life of garments by increasing their usage across multiple owners.



## Repair

Encouraging clothing repair can help shift consumer habits by promoting thoughtful purchases and longer garment lifespans. When customers invest in repairing instead of replacing, they are more likely to buy only what they need and hold on to their clothes for longer.

Several businesses are making it easier for consumers to choose repair as a sustainable alternative.

**The alterations and repairs business model focuses on extending the lifespan of garments through services like resizing, mending, and restoring. By offering these post-purchase solutions, companies cater to consumers seeking better fit and longer wear, while also helping reduce waste and promote sustainability.**

Alternew offers tailored solutions to extend the life of clothing through personalized alteration and repair services. The company partners with retailers and fashion brands through a subscription or software-as-a-service model, providing tools and logistics to streamline operations for tailors and partners. This model benefits consumers through improved garment fit and usability, supports brands by reducing returns and increasing loyalty, and empowers service providers with greater visibility and tech-enabled efficiency.

MendIt is a platform that connects individuals with local professionals who specialize in clothing repairs. Services range from minor fixes, such as button or hem replacements, to more complex repairs like zippers or full lining restorations.

SOJO provides a convenient door-to-door clothing alteration and repair service. Customers can book through the website or app, after which SOJO arranges collection, completes the requested tailoring or repairs, and returns the items directly to the customer's door.

Some established brands are also encouraging repair as part of their sustainability commitments. For example, Patagonia offers the 'IronClad Guarantee', which allows customers to return, replace, or repair products that are damaged or no longer perform as expected. This approach reinforces the brand's message of durability and responsible ownership.

## MUD Jeans

Through MUD Jeans' leasing program, customers can lease a pair of jeans for 12 months, with monthly payments starting at €10.80. During this period, MUD Jeans retains ownership of the raw materials, ensuring they remain part of a closed-loop system. At the end of the lease, customers have the option to keep the jeans at no additional cost, exchange them for a new pair, or return them for recycling. The program also includes free repairs during the lease period, along with a 10% discount on future leases, which helps build customer loyalty and encourages ongoing participation.

**MUD Jeans is a strong example of a circular fashion model by combining leasing, repair, and recycling services to reduce waste and extend the life of garments.**

MUD Jeans enhances its leasing model through a repair service that helps extend the lifespan of each product. Customers leasing jeans within Europe are eligible for free repairs during the one-year lease period, with shipping costs covered by the customer. Alternatively, if a customer chooses to handle the repair independently, MUD Jeans offers a reimbursement of up to €10 per repair. This service supports the brand's mission by keeping jeans in use for longer, reducing the need for new production.

The brand's recycling initiative completes the circular cycle. Returned jeans are carefully assessed, sorted, and categorized based on their condition. If an item is still wearable, it is resold as a vintage piece. Jeans that can be repaired are refurbished and returned to the leasing system. Those that are no longer usable are recycled into new fibers, minimizing dependence on virgin materials and contributing to MUD Jeans' sustainability goals.

Customers are responsible for the cost of returning items, with fees ranging from €4.95 to €9.95 depending on location. Additional customs charges may apply for returns sent from outside the European Union. However, exchanges are offered at no extra cost. MUD Jeans covers both the return and the shipment of replacement items. Returns can be initiated through a QR code on the MUD Jeans website, creating a simple and user-friendly process.

This system also supports reverse logistics by helping the company manage returns, track each item, and sort them appropriately for resale, repair, or recycling. In addition to its innovative business model, MUD Jeans is committed to transparency. Customers can access detailed information about the environmental impact of each product, helping them make informed choices.

Watch: Inside ACS Clothing's Rental, Resale, and Repair Models in Action on YouTube to learn how ACS Clothing' operates its rental, resale & repair models which operates similarly to MUD jeans.



Scan the QR code in this image to view a MUD Jeans' product journey

## Consumer Behavior and Sustainable Consumption Models

Consumer attitudes toward circular fashion are evolving. The stigma associated with secondhand shopping is diminishing, with 70% of consumers<sup>12</sup> now open to circular options such as resale, rental, and repair.



This shift is particularly evident in Western markets, where younger consumers are embracing secondhand clothing as both a sustainable and economic choice. However, in parts of Asia, concerns about hygiene and product quality still limit adoption. These perceptions are shaped by past exposure to poor-quality secondhand imports and limited quality assurance. In contrast, many Western consumers have fewer concerns, as resale platforms offer curated selections and emphasize cleanliness. Ultimately, the decision to buy, rent, or repair clothing depends on a combination of personal needs, behaviors, and values. As awareness of environmental impacts grow, more consumers are integrating sustainability into their purchasing decisions.

Younger generations, particularly those between the ages of 18 and 34, are the most receptive. Rising inflation has also encouraged consumers to consider secondhand as an affordable alternative.

Sustainability is not the only driver for circular consumption. In the United Kingdom, 33% of consumers say that reducing waste is a key motivation behind choosing circular options.

Aspect	Resale	Rental	Repair
Target Consumers	Budget-conscious, eco-conscious, and younger consumers seeking uniqueness.	Fashion-forward, younger consumers seeking flexibility and trendy options.	Sustainability-conscious consumers seeking durability and waste reduction.
Value Proposition	Affordable, unique, and high-quality products; reduces waste.	Access to high-end fashion at lower costs, flexibility without ownership burden.	Extending product lifecycle, fostering brand loyalty, and reducing waste.
Challenges	Maintaining high-quality inventory, ensuring trust and seamless shopping experience.	Operational efficiency, maintaining a diverse inventory for trend-driven market.	Efficient handling, timely processing, and consumer adoption.
Scalability Factors	Ensuring product quality, trust-building, and expanding inventory.	Strategic partnerships, inventory management, and logistics efficiency.	Operational excellence, technology adoption, and consumer education.
Key Examples	<a href="#">Poshmark</a> , <a href="#">ThredUp</a> , <a href="#">Depop</a> , <a href="#">The Real Real</a> , <a href="#">Future Reference</a>	<a href="#">Rent the Runway</a> , <a href="#">Nuuly</a> , <a href="#">Pickle</a>	<a href="#">MUD Jeans</a> , <a href="#">Alternew</a> , <a href="#">MendIt</a> , <a href="#">SOJO</a>

## Alternative Consumption vs. Retail Models

Alternative consumption models such as resale, rental, and repair offer environmental benefits when they reduce the need for new clothing production. Their impact depends not just on extending a garment's life, but in displacing new purchases.

Rental is effective when it replaces ownership. For example, if 10 people each buy 10 garments a year, that results in 100 new items produced. If the same group shares a rental pool of 10 garments, and those rentals fully replace purchases, production drops by 90%. This creates a 1 to 10 ratio, where one rented garment replaces 10 new purchases. This benchmark helps determine whether rental models are actually reducing production or just adding convenience. If the ratio falls below 1 to 7 ratio, traditional retail may be more sustainable.

Not all garments are suited for rental. Items like jeans and everyday shirts that are worn often are better owned. Rental is most effective for high-impact, low-use garments such as wool, leather, outerwear, and occasion wear. These are categories where sharing reduces production and emissions.

However, how rental is delivered also matters. Air shipping adds significant emissions and can offset benefits. Local fulfillment and peer-to-peer models avoid air freight and increase overall environmental savings.

Research<sup>16</sup> suggests that if a rented garment replaces fewer than 7 new purchases (a 1-to-7 ratio), the environmental benefits start to decline. This is because the energy and emissions from transporting, cleaning, and managing rentals may outweigh the savings from reduced production. In those cases, traditional retail might have a lower overall footprint. The real impact of resale or rental depends on whether it helps people buy less.

## Technology enabled Sustainable Consumption

Digital tools are helping consumers make more informed choices. Closet apps like OpenWardrobe, Whering, Indyx, and Alta offer features such as wear tracking, outfit planning, and cost-per-wear insights. These tools help users evaluate how often items are worn and encourage re-wearing or renting instead of buying. Platforms like Beni help consumers discover secondhand clothing across resale platforms. Its browser extension analyzes product details while users browse online and automatically suggests similar pre-owned alternatives using AI-powered product matching. Its app allows users to search directly and upload photos to find lookalike second hand items.

These tools and applications work when they lead to fewer new purchases and shift the focus from volume to value, encouraging more intentional consumption. By doing so, they play an important role in reshaping the retail model and supporting the transition to a more circular fashion system.

## Chapter SIX

# End of Life

According to the U.S. Environmental Protection Agency (EPA), approximately 15.4 million<sup>13</sup> tons of textiles entered the waste stream in 2018. Of this total, an estimated 85% was sent to landfills or incinerators, while only 15% was diverted for reuse or recycling. This reflects the ongoing difficulty in managing textile waste sustainably.

Once collected, used textiles are sorted and graded by quality. High-quality secondhand items, are typically resold in domestic or Western European markets. Second-grade textiles are exported to Eastern Europe<sup>14</sup> and the Middle East, while lower-quality garments are sent to markets in Asia. These redistribution practices highlight the limited reuse opportunities within national systems and the continuing dependence on export as a way to manage post-consumer clothing.

In Europe, recovery rates vary. Across seven countries, between 50 and 75% of textiles that are separately collected are reused. These represent about 38% of total post-consumer textile waste. An additional 10 to 30% of the collected textiles are recycled. The remaining portion is either incinerated for energy recovery or disposed of in landfills. Despite these systems, most used textiles are still thrown away with household waste. Around 62% of post-consumer clothing is not sorted for reuse or recycling. Instead, it is incinerated or landfilled, contributing to growing environmental pressures. This global textile waste problem arises from two key issues. First, most garments are not designed to be recycled or reused. Second, many countries do not have the infrastructure needed to sort, process, or recover textile waste.

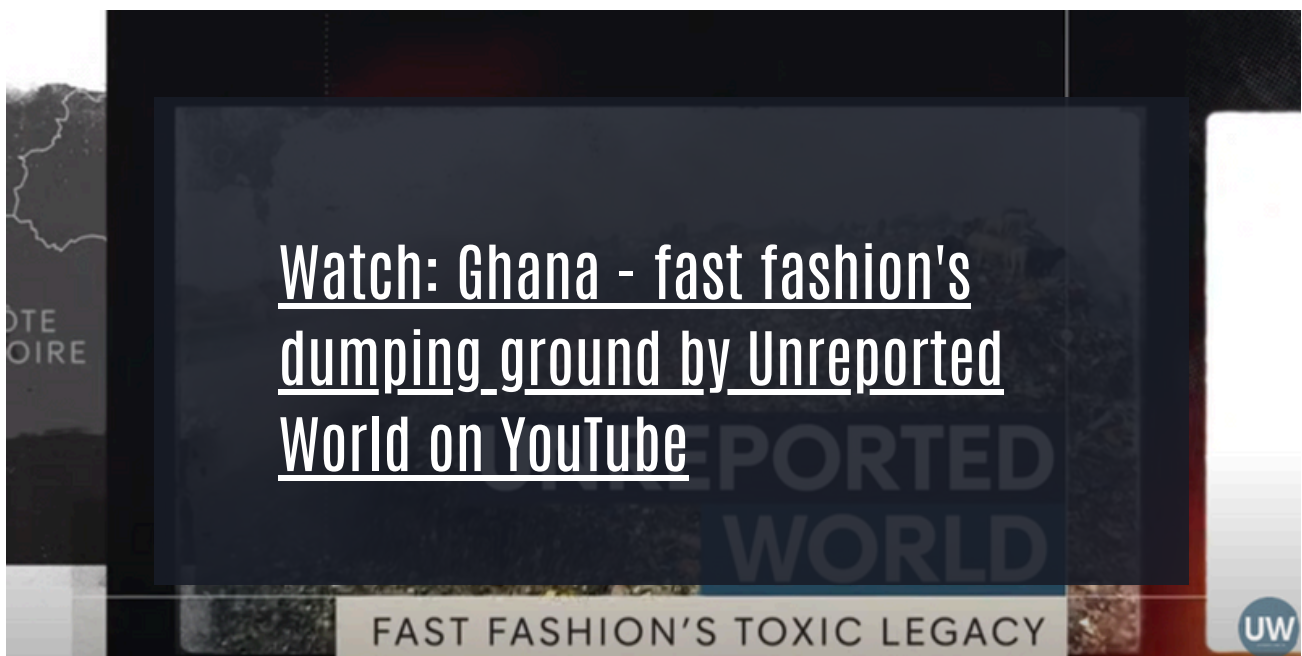
**Less than 1% of the raw material produced is recycled into new clothes and only 14% is recycled in some way.**

**Once textile waste is collected, sorters begin by identifying premium-quality secondhand clothing. This top tier, often called the "crème," represents only about 5% of the total collected volume and is typically resold in Western European markets.**



As a result, the burden of managing discarded clothing often falls on countries with the lesser resources.. In 2020, the United States was the largest exporter of used clothing. A significant portion of these exports goes to East Africa, a major market for secondhand garments. However, it is estimated that 30 to 40% of the clothing bales sent to the region cannot be sold due to poor quality or damage. Most countries receiving these exports do not have the infrastructure needed to manage the resulting waste. As a result, unsellable clothing often accumulates in landfills, dump sites, or is openly burned.

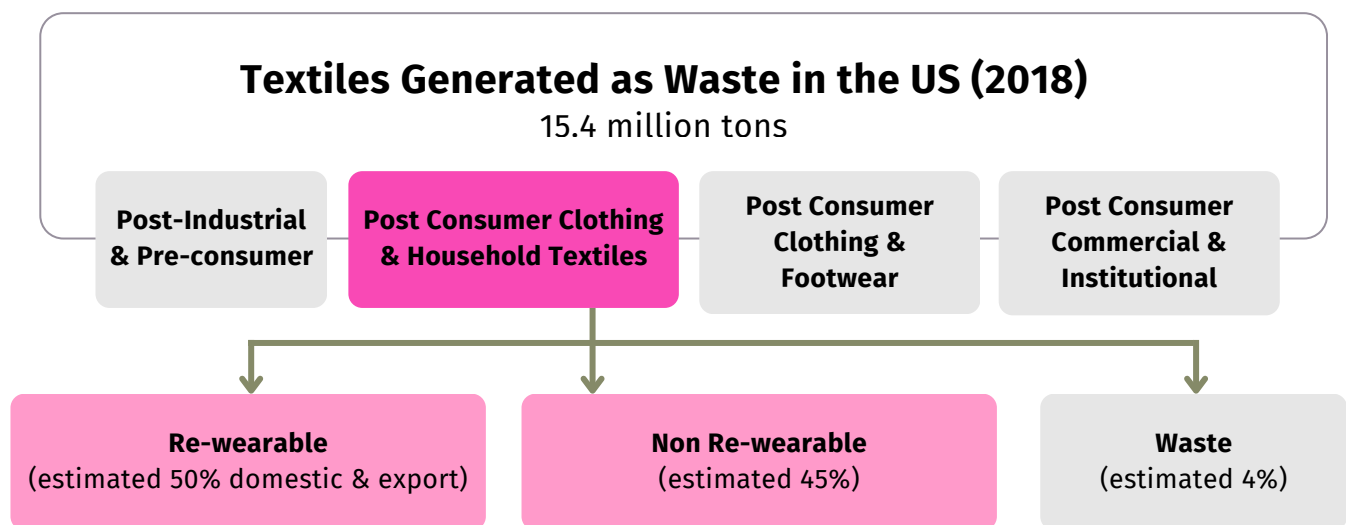
The challenge lies in both the lack of design for recyclability and the absence of local systems for waste management. This results in shifting the burden of textile waste to countries that are least equipped to manage it. Addressing this issue requires stronger international cooperation and investment. Several global initiatives, including the [United Nations Environment Program's Textile Initiative](#), the [European Union's Strategy for Sustainable and Circular Textiles](#), and programs led by the [Ellen MacArthur Foundation](#), aim to promote circular economy strategies, support extended producer responsibility, and build local recycling infrastructure. These efforts are essential to shift responsibility upstream and prevent waste at its source.



The textile recovery system in the United States operates through a complex network of generators, collectors, brokers, sorters, graders, and end markets. Unlike traditional supply chains, textiles do not follow predictable paths in reverse logistics. Some actors perform multiple roles, and materials may be exchanged several times before reaching their final destination.

Globally, large-scale clothing-to-clothing recycling does not yet exist. Mechanical recycling, which involves shredding textiles into fibers, often produces lower-quality material that cannot match the performance of virgin fibers. Although chemical recycling technologies offer the potential to regenerate fibers to near-virgin quality, these methods remain limited due to technological and economic challenges.

Currently, only about 2% of inputs used in clothing production come from recycled materials. Most of this is recycled polyester sourced from PET plastic bottles, commonly used by brands such as Adidas and Nike.



Source - [Fashion for Good Sorting for Circularity Report](#)

## Improving Textile Recycling

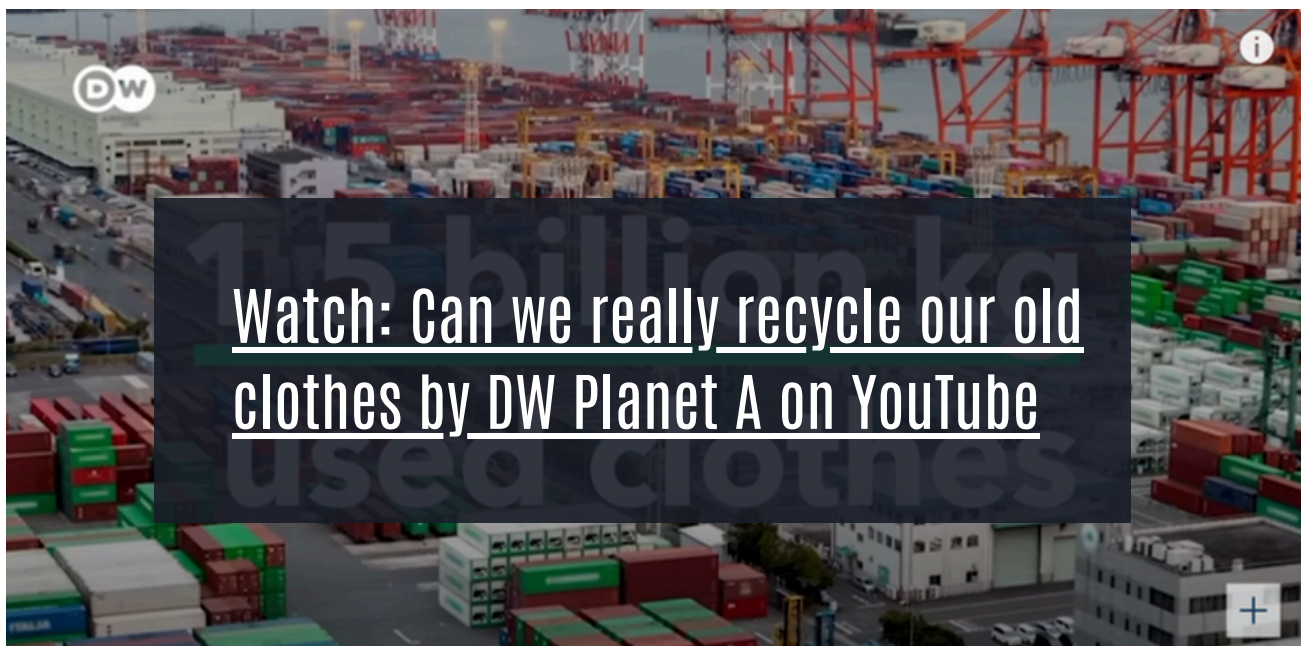
Developing efficient recycling processes is essential for scaling textile recovery and supporting a more circular fashion system. Several key areas require focus:

- **Designing for recyclability** - Creating new materials that balance performance with recyclability is critical. Materials must be engineered to maintain their function while also being easier to break down and reuse at the end of their life.
- **Integrating tracking technologies** - Implementing digital tracking and tracing features within clothing design can improve material identification throughout the value chain. Better traceability helps recyclers sort garments accurately, improving the quality of recycled output.
- **Ensuring accurate labeling** - Effective recycling depends on transparency and accurate detection of material content. Current labeling practices are often inadequate. For example, an item labeled as 100% cotton may include synthetic trims or blends, which can disrupt the recycling process.

To improve these systems, there must be a stronger connection between recyclers and product designers. This feedback loop can inform better design choices that make garments easier to recycle.

In addition, expanding textile recycling requires increased investment in infrastructure. Building low-cost and efficient sorting and recycling facilities is a key step toward enabling broader adoption and long-term success.

Recycling methods vary and include fabric recycling, yarn recycling, and fiber recycling. Each method presents its own set of challenges and opportunities in terms of cost, quality of output, and scalability.



As recycling systems evolve, technology plays an increasingly important role in addressing the complexity of textile waste. Manual sorting remains the industry norm in many regions, but emerging tools like artificial intelligence and automation offer promising solutions for improving efficiency, accuracy, and scalability. These innovations can help overcome key challenges in textile recycling and support the development of circular systems.

## AI's Potential

Artificial intelligence is modernizing textile recycling. Some sorting facilities have begun using semi-automated systems, and artificial intelligence offers significant potential to enhance these processes.

Machine learning models, including artificial neural networks (ANNs), are used to predict waste generation trends, helping organizations plan for recycling and disposal more effectively. Time series models can estimate future waste patterns, enabling better resource allocation and capacity planning.

For example, Greyparrot uses AI to analyze waste streams in real time, helping waste management companies identify and sort materials effectively.

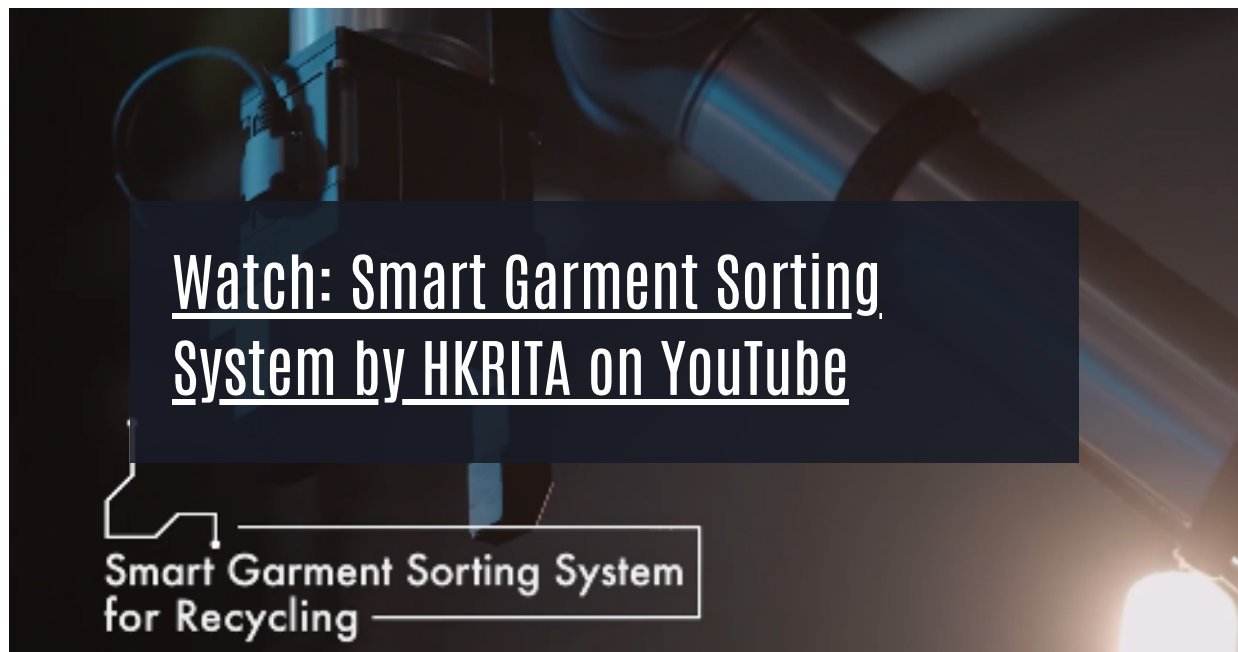
Convolutional neural networks (CNNs) are used to classify materials such as fibers, plastics, and glass, which supports more accurate sorting. When combined with robotics, CNNs enable the automation of sorting tasks.

In Spain, for example, a municipal sorting facility in Barcelona has implemented this technology that uses AI and computer vision to automate waste separation, improving efficiency and accuracy in waste processing. Innovative companies like Refiberd are leading the way by using AI-powered sorting technologies to identify materials that are suitable for recycling. Their systems analyze fabric composition to determine the most effective recycling pathway for each item. Governments are also supporting these waste sorting efforts. In the United Kingdom, the government funded one third of the cost of a FiberSort machine used by the Salvation Army. This technology uses infrared light to automatically sort textiles by fiber type, enabling them to be recycled more easily back into new textiles. Another example of AI-powered innovation in textile sorting is Smart sorting from H&M Foundation in collaboration with HKRITA.

After collection, used clothing is either sorted domestically or shipped abroad for processing. In Europe, much of the sorting is done manually. Workers assess the condition, fabric, and style of each item to determine its next destination.

This process also involves removing non-textile waste and categorizing reusable clothing based on market demand. Because this task requires skill and experience, it can take up to six months for workers to become proficient in textile sorting.

This system uses near-infrared spectroscopy combined with machine learning to automatically identify and sort textiles by fiber composition as manual methods for accurately sorting blended fabrics are slow and inconsistent,



Beyond sorting and classification, technologies such as blockchain are enabling end-to-end traceability across the fashion supply chain. These tools record key data points from sourcing to disposal, building transparency and accountability. Blockchain also helps in verifying material claims, tracking certifications, and supporting digital product passports, all of which are vital for sustainable product lifecycles.

One example is [TrusTrace](#), a traceability and compliance platform used by brands such as Adidas, Primark, and Tapestry. TrusTrace combines supplier data, AI-based pattern recognition, and blockchain-backed verification to map product journeys from raw material to finished garment. This enables brands to validate sustainability claims, track risks in the supply chain, and generate documentation for compliance with regulations like the EU's upcoming Digital Product Passport.

[TextileGenesis](#), adopted by brands like H&M, Adidas, and Lenzing, uses blockchain to trace fiber origin and movement across the supply chain. Each batch of sustainable fiber is tagged with a digital token that verifies its authenticity and environmental claims. Other efforts include [Arianee](#), which partners with fashion brands to issue digital certificates of ownership for garments, aiding resale and repair. These examples show how blockchain enhances accountability and strengthens trust across stakeholders, complementing AI's role in making circular fashion more scalable.

[Listen to this podcast by Amanda McCarty](#) on Clotheshorse whether AI can truly support circular fashion and sustainability.

## Chapter SEVEN

# Life Cycle Assessments

### Life Cycle Assessment (LCA)

To understand and reduce environmental impact, many brands and manufacturers rely on Life Cycle Assessment (LCA). LCA follows internationally recognized standards, specifically ISO 14040 (2006) and ISO 14044 (2006), and provides a structured approach to evaluating the environmental footprint of a product from raw material extraction to disposal. Read the [Beginner's Guide to Life Cycle Assessment \(LCA\)](#) by Ecochain about how LCA works and how results are interpreted.

The LCA methodology evaluates a product's environmental footprint across all stages of its life, from raw material extraction to production, use, and eventual disposal.

LCA helps quantify environmental impact across a range of categories. Some of the most commonly assessed areas include:

- Climate change - greenhouse gas emissions contributing to global warming
- Acidification - air pollution that affects soil and aquatic ecosystems
- Eutrophication - nutrient pollution in water bodies that disrupts ecosystems
- Toxicity - exposure to chemicals that affect human and environmental health
- Water depletion and land use - impacts on natural resources and ecosystems

These categories help businesses compare the environmental footprint of different materials, products, or design decisions. By identifying which life cycle stages have the highest environmental impact, companies can focus on those areas for the most effective improvements.

The LCA process itself follows four key steps. It begins by setting a clear goal and deciding what stages of the product life cycle will be included. Next, data is collected on all the materials, energy, water, and emissions involved. This information is then analyzed to understand how the product contributes to environmental issues such as carbon emissions or water use. Finally, the results are reviewed to identify opportunities for reducing environmental harm and making sustainable choices.





By offering measurable data, LCA results can guide product design by identifying opportunities to substitute high-impact materials with lower-impact alternatives or by encouraging products that are easier to repair, reuse, or recycle. In manufacturing, LCA findings can support energy optimization and cleaner production technologies, reducing operational emissions.

As consumer interest in product sustainability grows, incorporating LCA findings into marketing, labeling, and reporting can also enhance brand credibility and foster consumer trust. It is a key tool in building a more sustainable apparel industry.

LCA can support more informed purchasing decisions by highlighting the environmental performance of different products for consumers. For businesses, these assessments reveal which stages of the value chain contribute most to emissions, water usage, or resource depletion. Governments and policymakers can also use LCA-based evidence to develop regulations and incentives that support circular economy practices.

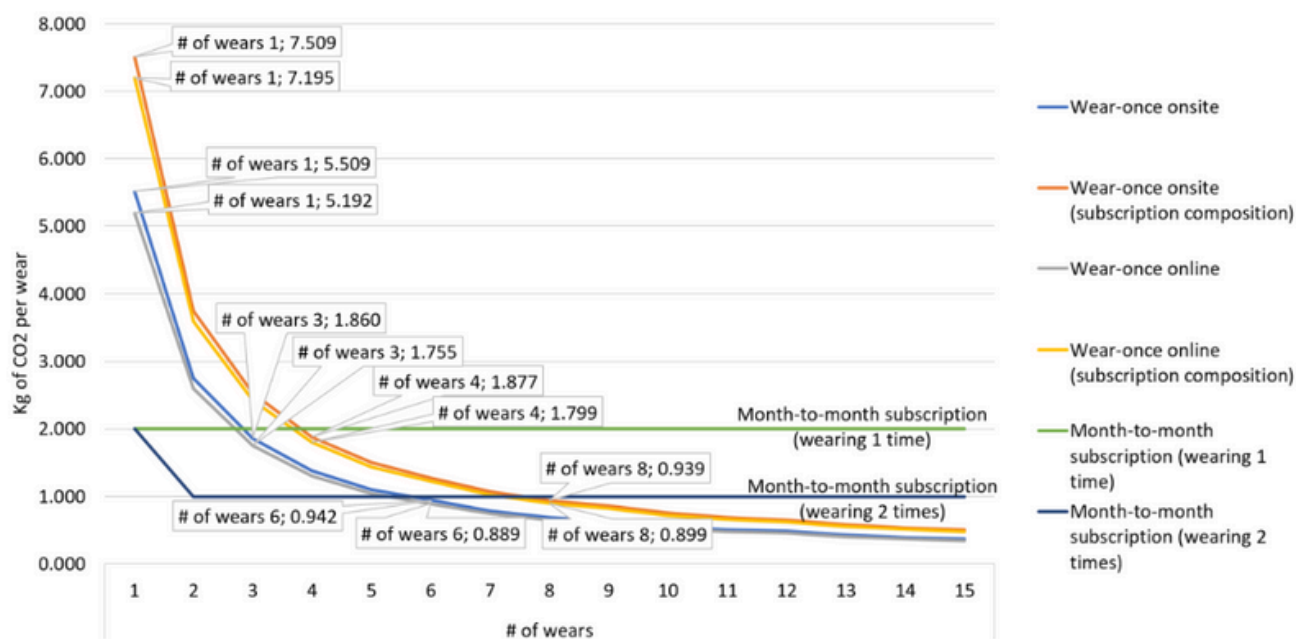
For an overview of the environmental impact categories commonly used in Life Cycle Assessment (LCA), read [Impact Categories in LCA by Ecochain](#). For a more comprehensive guide, the European Commission's [ILCD Handbook: General Guide for Life Cycle Assessment](#) outlines best practices for conducting LCA.



One example of how LCA can be used to evaluate business strategies comes from the [MIT Sustainable Supply Chain Lab](#). The study compared the environmental impacts of three fashion business models: monthly rental subscriptions, peer-to-peer rentals, and traditional purchasing. Several key insights emerged:

- Transportation and packaging - Rental subscription models tend to involve frequent deliveries and returns. These repeated trips, along with the high use of packaging materials, contribute to higher environmental impacts compared to conventional shopping.
- Casual versus occasion wear - For casual clothing that is worn multiple times, usually six to eight wears or more, purchasing is the more sustainable option. On the other hand, renting is the better choice for special-occasion outfits that are worn only once or twice.

## Circular Rental Models versus Wear-once Consumption



Source - [Rental vs Fast Fashion Clothing](#)

These findings show how LCA can help stakeholders make practical decisions and reduce environmental harm. Technology plays an important role in enabling this shift. In rental and resale models, technology can help coordinate returns, minimize packaging, and reduce transport-related emissions. When LCA is used together with traceability platforms, these tools make circular strategies more transparent, efficient, and easier to scale.

## Social Life Cycle Assessment (SLCA)

LCA focuses on measurable outputs like carbon emissions or water use and does not account for how products affect people. Social Life Cycle Assessment (SLCA) addresses this gap by evaluating the social and socio-economic impacts of a product from raw material extraction to final disposal.

Like environmental LCA, SLCA examines each stage of the value chain. However, the focus shifts to how the product affects workers, consumers, local communities, and society as a whole.

It uses social indicators to evaluate areas such as fair wages, labor conditions, workplace safety, community well-being, and consumer health. This broader perspective helps businesses and policymakers make decisions that consider both environmental and human impacts. For example, SLCA considers whether the workers who made a shirt received fair wages and worked in safe conditions. It also asks whether the manufacturing process harmed nearby communities or whether the final product is safe and free of toxic substances for consumers.

SLCA uses a combination of quantitative and qualitative methods to assess these factors. Metrics include compliance with wage standards, occupational safety benchmarks, stakeholder interviews, worker surveys, and third-party audits. These indicators help assess how a product affects people involved in its production and use. Learn about Guidelines for Social Life Cycle Assessment (SLCA) by the Life Cycle Initiative. This guide outlines how to assess social and socio-economic impacts across a product's life cycle..

Unlike environmental LCAs, which rely on physical measurements such as carbon emissions or water usage, SLCA deals with complex and context-dependent human experiences. This makes standardization more difficult and slows wider adoption. Social data is often less available, harder to verify, and more difficult to quantify at scale. As a result, many companies prioritize environmental LCAs because they offer more immediate, measurable insights for decision-making.

When used together, environmental LCA and SLCA offer a more complete view of a product's impact. This combined approach helps reveal trade-offs and guide better decisions about what we wear and how fashion is produced and consumed.

While Life Cycle Assessments are valuable tools for measuring environmental impact and resource consumption, they do not capture the full picture. It does not account for the social or economic effects of a product's life cycle.



Watch: Why do our jeans wear out so quickly? by Madhavi Venkatesan on TedTalk



Watch: How Fast Fashion Kills - Slave Labour, Toxic Waste and Catastrophic Pollution by Java Discover on YouTube

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## Chapter EIGHT

# Certifications & Greenwashing

### Current State

One commonly promoted practice is the use of recycled materials, such as polyester made from discarded plastic bottles. While this may seem like a positive step, the process of converting plastic into fabric still consumes energy and resources. Additionally, the long-term recyclability of these garments remains uncertain. In many cases, these materials cannot be recycled again after use, which limits their role in a circular system.

This disconnect between messaging and action has led to growing concerns about greenwashing. Brands use sustainability related language to improve their image, even if their practices on sustainability have not changed significantly. These claims mislead consumers into believing that a product is more sustainable than it actually is.

It is important for consumers to recognize that the use of sustainable materials, such as organic cotton or recycled polyester, does not guarantee that a product is environmentally responsible.

The overall sustainability of a garment depends on a combination of factors, including how the materials are sourced, how the item is produced, and what happens to it after use. Without transparency in these areas, sustainability claims can be incomplete or misleading.

Many fashion brands today promote their products as eco-friendly using labels such as "75% recycled fiber," "100% recycled polyester," or "made with at least 20% recycled content."

Although these labels suggest a commitment to sustainability, they are often presented without supporting certification or verified data. As a result, it becomes difficult to determine whether these brands are truly acting responsibly or simply using sustainability as a marketing strategy.

A well-known example of greenwashing involved H&M in the Netherlands. The company was found to have used vague and unsubstantiated sustainability claims in its marketing, leading to a formal investigation by the Netherlands Authority for Consumers and Markets (ACM). Terms like "ecodesign" and "conscious" were used without clear definitions or evidence to support the environmental benefits being advertised. These claims were considered potentially misleading to consumers.

As a result of the investigation, H&M agreed to pay half a million euros to independent organizations that promote sustainability. Although the company stated that it does not support greenwashing, it acknowledged the need for clearer communication and agreed to discontinue the use of these ambiguous labels.

Cases like this highlight the importance of regulatory oversight and transparency. To address greenwashing more effectively, there is a growing call for stronger rules and accountability.

Companies should be required to substantiate environmental claims, and sustainability standards should be integrated into legal frameworks rather than left as voluntary commitments.



[Watch: Exposing the secrets of sustainable fashion by CBC News on YouTube](#)

## Industry Certifications and Standards

In response to widespread greenwashing in the fashion industry, several global standards and certifications have been established to promote accountability and ensure that sustainability claims are backed by verified practices.

Certifications offer transparency, guiding consumers to products that meet verified environmental and social standards.



**Global Organic Textile Standard (GOTS)** - GOTS is one of the most widely recognized certifications for organic textiles. It ensures that organic fibers are used and that harmful chemicals are avoided throughout the production process. The certification also verifies that the product was manufactured in a socially and environmentally responsible manner.



**Oeko-Tex** - Oeko-Tex certifies textiles that have been tested for harmful substances. The STANDARD 100 by Oeko-Tex confirms that every component of a product—including fabric, thread, buttons, and zippers—has been evaluated against a list of regulated and non-regulated harmful chemicals. Additional certifications under the Oeko-Tex umbrella include MADE IN GREEN, which assesses environmentally friendly and socially responsible production, as well as ORGANIC COTTON and LEATHER STANDARD.



**Cradle to Cradle Certification** - The Cradle to Cradle Certified Product Standard, developed by the Cradle to Cradle Innovation Institute, focuses on designing products with circularity in mind. It promotes circular sourcing, product design for reuse or recycling, and systems that support material recovery and continuous use within the economy.





**Fair Trade Certification** - This certification guarantees that producers—particularly in developing countries—are paid fair wages and work under safe conditions. It also ensures adherence to environmental and ethical standards while supporting community development and long-term economic sustainability.

**Other Certifications** - Several other certifications contribute to responsible fashion practices. The Bluesign System focuses on sustainable chemical use and resource efficiency during manufacturing. Cradle to Cradle Certified, mentioned earlier, applies to a broad range of consumer products and materials that meet strict health, environmental, and design standards.

Together, these certifications play a vital role in verifying sustainability claims and reducing misinformation. They help consumers make informed choices and encourage brands to adopt higher standards throughout their supply chains.





## Chapter NINE

# Policy & Regulations

Governments and regulatory bodies are playing an increasingly important role in shaping a more sustainable fashion industry. As voluntary efforts from brands often fall short, regulatory frameworks are becoming increasingly important to ensure transparency, accountability, and environmental performance.

To further support circularity, the EU has introduced the Eco-Design Framework. This proposal requires companies to disclose information about a product's carbon footprint, environmental impact, recycled content, durability, reusability, upgradability, and repairability. These details will be made available through a Digital Product Passport (DPP), which is being introduced in a phased rollout across the region. The DPP system will become mandatory for products sold in the EU, with full implementation expected by 2033. Each product will carry a unique identifier, such as a QR code, that links to comprehensive data on material composition, origin, environmental performance, and guidance on repair and recycling.

Key metrics will be based on Life Cycle Assessment (LCA) methodologies and may include greenhouse gas emissions, energy usage, and water consumption.

New laws and frameworks are driving investment in recycling infrastructure, holding brands accountable for their environmental impact, and encouraging a shift toward circular systems.

One major development is the EU's 2025 textile waste collection requirement<sup>15</sup>. This regulation mandates that member states establish systems for separate textile waste collection, prompting retailers and manufacturers to adopt more responsible end-of-life solutions.

For consumers, this regulation will offer greater access to information, empowering them to make informed purchasing decisions and encouraging a more sustainable approach to fashion. For businesses, it will drive innovation in product design, sourcing, and supply chain management. It also has the potential to influence brand reputation and customer loyalty by linking sustainability performance to the overall value proposition.

Under the French policy, clothing brands are required to either manage the collection and recycling of their own products or contribute financially to ReFashion, an organization that partners with the French government to oversee textile recycling.

Similar EPR policies have been adopted in the Netherlands, Hungary, and Latvia. Proposals are also under consideration in the broader European Union, as well as in Kenya, the State of New York, and the State of California.

France has been a pioneer in this space. In 2007, it introduced an Extended Producer Responsibility (EPR) law for textiles.

By 2019, France aimed to reuse, recycle, or convert 95% of its textile waste into energy, with only 2% sent to landfill. This led to a sharp rise in textile collection, increasing from 65,000 tons in 2006 to 249,000 tons in 2019.

### Challenges and Opportunities in Developing Economies

While developed countries have begun investing in textile collection and recycling infrastructure, developing economies face a different set of challenges. To stay competitive in a globalized market, many fashion brands outsource production to low-wage countries in Asia. Although this keeps costs down, it often comes at the expense of environmental responsibility and workers' rights in those developing economies.

In 2023, developing nations such as Bangladesh, India, Sri Lanka, and Vietnam accounted for 31% of apparel imports to the European Union and 35% of imports to the United States. Along with China, these countries are essential to supporting the fast fashion model, which relies on speed, volume, and low prices. As a result, these countries contribute significantly to global fashion-related emissions through energy-intensive manufacturing and limited access to clean technology.

Despite their importance to the global fashion industry, many production hubs struggle to implement sustainable practices. Regulatory oversight is weak, financial support for innovation is limited, and public awareness of sustainable fashion is still growing. At the same time, infrastructure for textile recycling and circular systems remains underdeveloped.

These regions also hold strong potential to drive the transition to a more sustainable future. Their key role in apparel manufacturing offers a unique chance to integrate circular practices such as waste reduction, material reuse, and resource-efficient technologies directly into the supply chain. With the right support systems, this approach can create meaningful impact at scale.

Fashion consumption and environmental impact also vary widely across G20 countries, underscoring the need for context-specific strategies. High-income countries like Australia, Japan, and the United States record the highest per capita fashion emissions, ranging from 387 to 503 kilograms of CO<sub>2</sub> equivalent per person. These levels are driven by high purchase volumes and shorter garment use. In contrast, India has the lowest fashion footprint in the G20, at just 22 kilograms of CO<sub>2</sub> equivalent per person, reflecting more restrained consumption and longer wear times.

While developing countries are major production hubs and account for a large share of global apparel manufacturing emissions, their domestic fashion consumption is low. In markets like India and Brazil, people tend to purchase fewer garments, use them for longer periods, and repair them before discarding. These habits help keep emissions from the use phase relatively low and support more sustainable practices.

**Globally, approximately 84% of fashion-related emissions are linked to upstream activities like fiber production and garment manufacturing. These stages are resource-intensive and energy-heavy.**

This trend is beginning to change in those countries. As incomes rise and more people move into the middle class, fashion consumption is increasing. Greater purchasing power and exposure to global fast fashion are leading to more frequent buying and shorter garment lifespans. Without timely intervention, these shifts could lead to the same overconsumption patterns seen in high-income countries.

Despite these emerging risks, many households in India and Brazil still remain within the fashion-related carbon budget of 128.7 kilograms of CO<sub>2</sub> equivalent per person per year, which aligns with the 1.5-degree climate target. This suggests a strong starting point for promoting low-impact fashion consumption, built on extended garment use and repair habits. But this foundation may not hold without proactive efforts to educate consumers and guide purchasing behaviors as spending power grows.

To scale sustainable practices in these regions, several barriers must be addressed:

- Regulatory frameworks are often weak and enforcement is inconsistent
- Government support and subsidies for sustainability initiatives remain limited
- Short-term profit goals frequently outweigh long-term environmental concerns
- The high cost of adopting circular practices, such as recycling technologies, can be prohibitive
- Consumer demand for sustainable products is still low in many domestic markets
- Informal acceptance of secondhand clothing exists, but formal systems for resale and reuse are lacking
- Supply chains are fragmented, and coordination among manufacturers, suppliers, and retailers is limited

Addressing these challenges will require collective action. Governments can strengthen enforcement, provide targeted funding, and implement public awareness campaigns. Businesses and global institutions can support capacity building, technology transfer, and infrastructure development. With aligned efforts, developing economies can not only improve domestic sustainability outcomes but also help reshape global supply chains in favor of circularity.

Importantly, these countries are already well positioned to lead in some areas. Long-standing cultural norms around repair and reuse provide a valuable platform to formalize circular systems. With the right tools, partnerships, and policy support, developing economies can play a pivotal role in transforming fashion into a more inclusive and sustainable global industry.

# Chapter TEN

## Path Forward

Many solutions explored in this e-book such as lab-grown cotton, chemical textile recycling, waterless dyeing, AI-powered sorting, nearshoring, and reverse logistics exist today, but are fragmented, costly, or limited in scale. Their adoption faces barriers of infrastructure, consumer inertia, and, most of all, profitability. In a highly competitive industry where brands operate on thin margins, shifting to sustainable practices requires long-term investment and a rethinking of value creation.

**The vision for a truly circular fashion system is where materials continuously recirculate, waste is minimized, and new products are created without consuming new resource. But for this vision to become reality, one critical question remains: What will it take to profitably scale these innovations?**

Transitioning to circular fashion requires more than innovation alone. Without government grants, legislation, and regulatory mandates, change will remain voluntary and slow. Without international cooperation, efforts risk being siloed and sustainable practices in one region may be undermined by fast fashion supply chains in another. And without consumer education and incentives, circular products could end up in a landfill. Policy frameworks like the EU's Digital Product Passport (DPP), Extended Producer Responsibility (EPR) laws, and rising demand for ESG transparency are pushing the industry forward. Younger consumers are embracing conscious consumption as a form of identity, demanding more from the brands they support.

**Yet one of the biggest question is: Can cradle-to-cradle systems be efficient and profitable at scale? In theory, continuous re-circulation reduces dependency on virgin resources. But in practice, materials degrade, and reverse logistics are complex and costly. To make this work, we must design with circularity in mind by standardizing fibers, improving traceability, and fostering collaboration across the value chain.**

The current fashion model is linear. It follows a take-make-dispose pattern that relies on extracting raw materials, producing at scale, and encouraging short-term use. This system has led to overproduction, excessive waste, and unsustainable levels of resource consumption. A circular model, where materials are reused, shared, and regenerated, offers a necessary alternative. It helps reduce environmental impact by extending product life and minimizing the need for virgin resources.

Each player in the value chain: consumers, brands, manufacturers, retailers, policymakers, researchers, and technology providers, have a specific role to make fashion more sustainable. Together, these actions can help shift the industry away from overconsumption and toward a system rooted in reuse, responsibility, and regeneration.

### Consumers:

Consumer behavior plays a central role as consumers have the power to influence the entire system through everyday choices. Without sufficient demand, even the most promising innovations struggle to succeed. A compelling example is Circulose, a material made from recycled cotton textiles. Despite its technological strength and supply readiness, low consumer awareness led to weak demand. As brands reduced their orders, the solution failed to scale. This highlights the importance of consumer participation in driving sustainable change.

To accelerate the shift in consumption, consumers can engage more critically with the products they buy. Consumers should feel empowered to ask critical questions:

- Where and how are clothes made?
- What materials are used, and what is their environmental impact?
- What happens to garments after use?
- How are brands and policymakers addressing sustainability challenges?

By seeking transparency and holding brands accountable, consumers can drive meaningful change. These small but intentional actions create meaningful demand signals, encouraging businesses to invest in circular models and move away from wasteful practices.

**Buying less, supporting sustainable brands, extending the life of garments, and embracing secondhand or rental options can collectively reduce environmental impact and signal a shift in values. These choices help redefine sustainability as a shared standard rather than a preference. For example, research from Depop shows that 90% of secondhand purchases directly replace a new item, saving an average of 7.9 kilograms of CO<sub>2</sub> per item. Depop users also wear their items approximately 46 times, far exceeding fast fashion norms.**

## Businesses and Entrepreneurs:

Business managers and entrepreneurs play a central role in shifting the fashion industry from a linear model to one that supports circularity. It requires a fundamental rethinking of design, operations, and customer engagement. Circular strategies include producing longer-lasting garments, enabling repair and reuse, building resale and rental channels, and offering take-back or recycling programs. While product innovation is essential, it must be supported by changes in how businesses communicate value to consumers.

Research shows that presentation significantly influences consumer behavior. A research study tested how verbal and visual nudges influence consumer decisions when selecting between a sustainable cotton T-shirt and a regular one. In the verbal nudge condition, a clear statement was shown alongside the product - "This T-shirt is part of the Conscious collection. It is made with organic cotton, which has a lower impact on the environment than regular cotton." This message led to 72.9% of participants selecting the sustainable product. The visual nudge was through a branded banner displayed earlier in the shopping process, resulted in a 55.3% selection rate. In the control group, where no sustainability-related message appeared, only 44.9% chose the sustainable option ([Roozen et al., 2021](#)). These findings highlight the importance of using emotionally resonant and informative language across product pages, digital marketing, and in-store signage to guide consumers toward sustainable decisions.

**Another experiment found that when the environmental benefits of slower shipping were framed in relatable terms, such as "trees saved" instead of "kilograms of CO<sub>2</sub> reduced," consumers were more likely to choose low-impact delivery options ([Velazquez Martinez et al., 2024](#)). This suggests that brands can encourage more sustainable choices by presenting information in ways that feel tangible and personally meaningful, using clear and emotionally engaging messages across digital and physical touchpoints.**



Emotional connection to clothing also plays a role in encouraging long-term use. Luxury brands have long used customization and personalization to foster product attachment and discourage disposability. This approach is supported by research showing that secondhand luxury buyers often treat purchases as future assets, driven by the potential for resale. Businesses across all price points can apply similar strategies by promoting garment longevity and providing care information that helps consumers extend product life.

Product storytelling can further support adoption, especially for resale and rental services. Research shows that providing background information about a garment, such as who previously owned it or its personal history, can significantly increase consumer trust and perceived value. A study found that when secondhand clothing listings included personal narratives, consumers reported stronger emotional connection, greater trust, and higher intention to purchase (Kim et al., 2021). Businesses can integrate product history into packaging, apps, or online listings to create a more meaningful and engaging experience for customers.

Transparency is another critical enabler of circular fashion. Digital Product Passports are an emerging solution that helps businesses share detailed information with consumers, such as material composition, production location, carbon impact, and care instructions. MUD Jeans has begun piloting DPPs and blockchain-based systems to support traceability and consumer education. These tools not only build credibility but also create a feedback loop that connects sustainable design with informed consumer action.

### Polymakers:

Polymakers lay the foundation for circular practices to scale by setting the rules that govern industry behavior. Legislative tools such as Extended Producer Responsibility and the European Union's Digital Product Passport framework help establish accountability across the entire product lifecycle. These policies encourage brands to disclose environmental information, take responsibility for end-of-life treatment, and adopt more transparent business models. While regulation is essential, policy design must also consider how people make choices. Behavioral research shows that consumers respond more positively to sustainability cues when information is presented clearly and meaningfully.

This insight suggests that policy interventions should not only require disclosure but also use behaviorally informed tools such as eco-labeling and standardized product messaging to encourage adoption. Public investment is also critical. Government support for infrastructure such as textile collection systems and material recovery facilities helps lower the barriers for both businesses and consumers. In parallel, public education campaigns can increase awareness of circular practices and build the cultural readiness required for behavior change.

**There is also an opportunity for governments to support certification programs that are consistent, transparent, and easy to understand. A robust policy framework can reduce uncertainty and help consumers make more confident choices and building trust in circular products.**

Without this type of systemic support, sustainability initiatives risk remaining fragmented and dependent on voluntary action alone.

### **Researchers:**

Researchers play a critical role in driving a more sustainable fashion system by generating evidence-based insights across material science, behavioral economics, environmental impact, and consumer psychology. Their work helps identify what drives positive change and where barriers still exist, shaping more effective strategies across business, policy, and consumer behavior.

Beyond knowledge generation, researchers support the development and evaluation of sustainability policies. By partnering with governments and institutions, they assess circular economy initiatives and recommend improvements, ensuring programs are grounded in data and aligned with long-term environmental goals.

Researchers also provide essential tools such as Life Cycle Assessment models, standardized reporting frameworks, and sustainability benchmarks. These tools help businesses track impact, inform consumer communication, and guide policymakers in setting measurable standards.

As the fashion industry continues to evolve, researchers will remain a critical part of its transformation. Their work not only informs today's practices but also helps anticipate future challenges, drive technological advancement, and shape the education and training needed for the next generation of circular economy leaders.

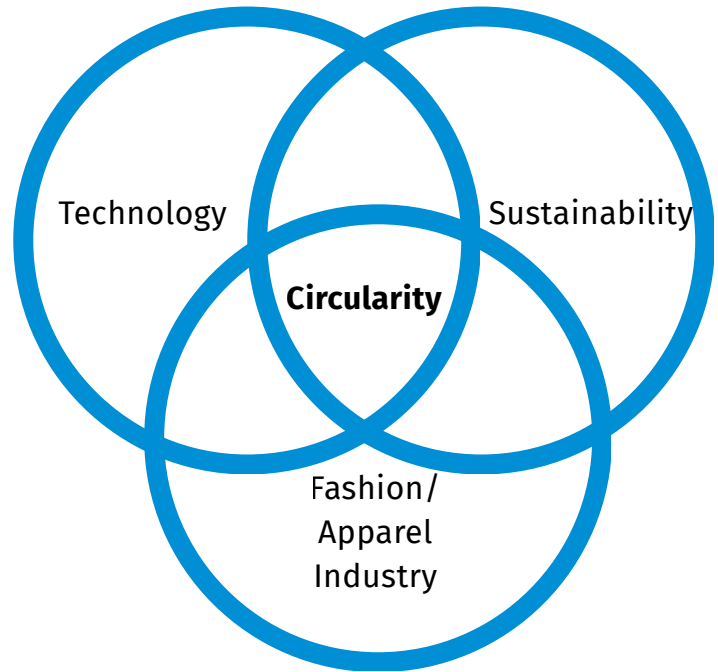
## Conclusion

Circular fashion system is within reach, but achieving it will require shared responsibility, strong leadership, and commitment to long-term change from every part of the ecosystem. When consumers, businesses, researchers, and policymakers align around a common goal, the industry can shift away from a model rooted in excess and move toward one based on regeneration, resource efficiency, and equity.

Throughout this e-book, we explored practical solutions such as material innovation, resale and rental models, textile recycling, and policy frameworks. These are supported by emerging technologies like Digital Product Passports and AI-powered sorting, which enable greater transparency, efficiency, and accountability. Technology is also driving new business models that extend product life and reduce overconsumption. Resale marketplaces, and repair-on-demand services all leverage digital infrastructure to make circular fashion accessible and scalable.

These innovations create an opportunity to decouple economic growth from increased production. By shifting the focus from volume to value, fashion businesses can adopt new models that extend product life and reduce waste.

As the fashion industry looks to the future, the integration of sustainability, fashion design, and technology offers a roadmap for circularity. When these elements work together, they can create a fashion system that is environmentally responsible, economically viable, and socially inclusive.



**To support this transformation, circularity must be positioned at the intersection of fashion, sustainability, and technology. This convergence creates opportunities not only to reduce waste but also to reimagine how fashion is designed, produced, consumed, and reused.**

# Additional Resources & Reading

## **Resources to learn more about Sustainability and Circularity in Fashion**

UN Alliance for Sustainable Fashion - <https://unfashionalliance.org/>

[Ellen MacArthur Foundation](#)

[Textile Exchange](#)

[Fashion For Good](#)

[Sustainable Fashion Forum](#)

[CFDA Sustainability Resource Hub](#)

[American Circular Textiles](#)

[Global Fashion Agenda's Upstream Circularity Podcast](#)

[Cascale](#) - To read about Higg Index

## **Podcast on Sustainable fashion:**

<https://clotheshorsepodcast.com/episodes/20/>

Crash Course Fashion Podcast - Available on Spotify and Apple Podcast

## **Videos & Documentaries:**

The True Cost Film - <https://www.youtube.com/watch?v=rwp0Bx0awoE>

Buy Now: The Shopping Conspiracy (A Netflix documentary) - Watch on Netflix



# References

- 1 - Ellen MacArthur Foundation. (2019, September 15). Fashion and the circular economy – Deep dive. <https://www.ellenmacarthurfoundation.org/fashion-and-the-circular-economy-deep-dive>
- 2 - Maiti, R. (2025, January 20). The environmental impact of fast fashion. Earth.org. <https://earth.org/fast-fashions-detrimental-effect-on-the-environment/>
- 3 - Ellen MacArthur Foundation. (2017). A new textiles economy: Redesigning fashion's future. <https://www.ellenmacarthurfoundation.org/a-new-textiles-economy>
- 4 - European Parliament. (2020, December 29). The impact of textile production and waste on the environment (infographics). <https://www.europarl.europa.eu/topics/en/article/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographics>
- 5 - Wren, B. (2022). Sustainable supply chain management in the fast fashion industry: A comparative study of current efforts and best practices to address the climate crisis. Cleaner Logistics and Supply Chain, 4, 100032. <https://doi.org/10.1016/j.clscn.2022.100032>
- 6 - McFall-Johnsen, M. (2020, January 31). These facts show how unsustainable the fashion industry is. World Economic Forum. <https://www.weforum.org/stories/2020/01/fashion-industry-carbon-unsustainable-environment-pollution/>
- 7 - Fashion Revolution. (2023). Fashion transparency index 2023. [https://issuu.com/fashionrevolution/docs/fashion\\_transparency\\_index\\_2023\\_pages](https://issuu.com/fashionrevolution/docs/fashion_transparency_index_2023_pages)
- 8 - Cosgrove, E. (2022, December 30). See inside a massive warehouse that handles returned clothes for major fashion brands. Business Insider. <https://www.businessinsider.com/what-happens-when-you-return-a-piece-of-clothing-2022-12>
- 9 - Coscieme, L., Akenji, L., Latva-Hakuni, E., Vladimirova, K., Niinimäki, K., Henninger, C., Joyner-Martinez, C., Nielsen, K., Iran, S., & D'Itria, E. (2022). Unfit, unfair, unfashionable: Resizing fashion for a fair consumption space. Hot or Cool Institute. [https://hotorcool.org/wp-content/uploads/2022/12/Hot\\_or\\_Cool\\_1\\_5\\_fashion\\_report\\_.pdf](https://hotorcool.org/wp-content/uploads/2022/12/Hot_or_Cool_1_5_fashion_report_.pdf)
- 10 - Cooper, T., Hill, H., Kininmonth, J., Townsend, K., & Hughes, M., with Shorrocks, J., Knox, A., Fisher, T., & Saicheua, V. (2013, May). Design for longevity: Guidance on increasing the active life of clothing (Final report, Project code: RNF100-012). Nottingham Trent University. [https://www.wrap.ngo/sites/default/files/2020-10/WRAP-Design%20for%20Longevity%20Report\\_0.pdf](https://www.wrap.ngo/sites/default/files/2020-10/WRAP-Design%20for%20Longevity%20Report_0.pdf)
- 11 - Recycling Magazine. (2023, January 18). New study: Clothing reuse has a 70 times lower environmental impact compared to producing new clothing. <https://www.recycling-magazine.com/2023/01/18/new-study-clothing-reuse-has-a-70-times-lower-environmental-impact/#:~:text=The%20environmental%20impact%20of%20reusing,quality%20clothing%20that%20is%20reused.>
- 12 - Mintel. (2023). US circular shopping market report 2023.
- 13 - Fashion for Good. (2024, May). Sorting for circularity USA: A commercial assessment of fibre-to-fibre recycling in the U.S. <https://www.fashionforgood.com/case-study/sorting-for-circularity-usa/>
- 14 - NORION Consult, & EuRIC. (2023, January). LCA-based assessment of the management of European used textiles. [https://circulareconomy.europa.eu/platform/sites/default/files/2023-02/LCA-based%20assessment%20of%20the%20management%20of%20European%20used%20textiles\\_corrected.pdf](https://circulareconomy.europa.eu/platform/sites/default/files/2023-02/LCA-based%20assessment%20of%20the%20management%20of%20European%20used%20textiles_corrected.pdf)
- 15 - European Commission. (2023, July 5). Proposal for a directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste (COM(2023) 420 final, 2023/0234 (COD)) [Legislative proposal] [https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive\\_en](https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en)
- 16 - MIT Center for Transportation & Logistics. (n.d.). Rental vs fast fashion clothing. Retrieved [2025, April 08], from <https://sustainable.mit.edu/rentalclothing/>