GLOBAL INSTITUTE FOR CIRCULAR ECONOMY & SDGS

Closing the Loop

Circular Economy in the Global Textile Sector

From Fibre to Landfill — and Back Again

Dr Shalini Sharma

First Edition · 2026

ICE & SDGs

GLOBAL INSTITUTE FOR CIRCULAR ECONOMY AND SUSTAINABLE DEVELOPMENT GOALS (ICE&SDGs)

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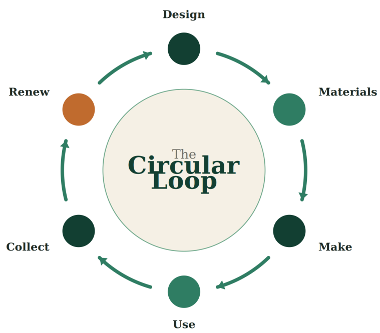

A practical guide to waste, impact and circular design across the world's textile value chain

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About this book

The textile and clothing industry clothes the world, employs tens of millions of people and drives economies on every continent. It is also one of the most resource-hungry and polluting industries on Earth. This book explains, in plain language, how textiles are made, how much waste they create, why that waste is harming the planet, and — most importantly — how the circular economy offers a practical way out.

It is written for a broad readership: sustainability and ESG professionals, brand and supply-chain teams, policymakers, students, and any curious reader who wants to understand the full journey of a garment and what can be done differently. The figures are drawn from recent industry and government sources; a short list of references appears at the end.

How to read this book

Chapters 1–2 set the scene: the scale of the industry and how it is made and polluted around the world.

Chapters 3–5 follow a textile through its life, and confront the waste crisis at the end of it.

Chapters 6–9 turn to solutions — treatment, circular-economy principles, and a stage-by-stage plan to close the loop.

Contents

The nine chapters move from the scale of the industry, through the life and waste of a textile, to the circular response. Four reference sections then follow: a catalogue of the world's fabrics, a circular-economy model for each, those models shown in action with their markets, and guidance for fabrics that have no circular value.

PREFACE

Why textiles, why now

Every second of every day, the world produces about four tonnes of new textile fibre — and buries or burns roughly a truckload of textiles. Those two facts, side by side, describe an industry running in a straight line: take, make, use, throw away.

For most of the last century, that linear model looked like progress. Clothing became cheaper, faster and more abundant than at any point in human history. But the same system that filled our wardrobes has drained rivers, poisoned waterways, filled landfills on other continents and locked billions of tonnes of usable material into a one-way trip to waste.

The good news is that the industry is not condemned to stay linear. The circular economy — an approach that keeps materials in use for as long as possible, at their highest value, and regenerates rather than degrades natural systems — gives textiles a credible path forward. It is already reshaping regulation in Europe, the United States and Australia, and it is opening real commercial opportunities in resale, repair, rental and recycling.

This book brings those threads together. It looks honestly at the scale of the problem and just as seriously at the solutions, ending with a stage-by-stage map of where circularity can be built into the textile value chain and how to begin.

CHAPTER ONE

The Global Textile Sector

Textiles are among the oldest and most universal of human technologies. Today they are also one of the largest and fastest-growing manufacturing sectors on the planet — and understanding their sheer scale is the first step to grasping both the problem and the opportunity.

An industry of extraordinary scale

Global fibre production reached roughly **132 million tonnes in 2024**, up from about 125 million tonnes the year before and from just 58 million tonnes in 2000. Production has **more than doubled this century**, and on current trends it is projected to climb to around 169 million tonnes by 2030. That is equivalent to producing about four tonnes of fibre every single second.

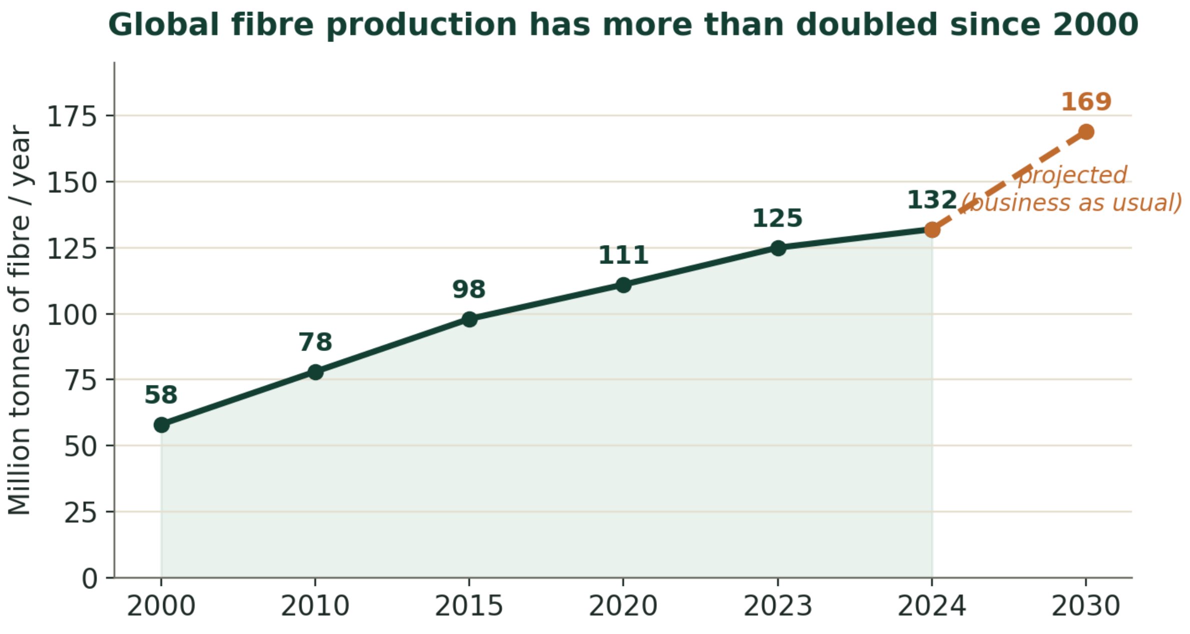


Figure 1.1 — Global fibre production, million tonnes per year. Growth shows no sign of slowing.

The fibre mix has shifted decisively toward fossil-based synthetics. **Polyester now accounts for about 59% of all fibre produced**, and roughly 88% of polyester is made from virgin petrochemicals. Cotton, the second-largest fibre, makes up around 19% (about 24.5 million tonnes), while man-made cellulosics such as viscose and lyocell account for around 6%. Recycled fibres remain a small slice — about 7.6% of the total — and almost all of it comes from recycled plastic bottles rather than from old textiles.

A pillar of the world economy

Behind these volumes sits an economic giant. The textile and apparel industry is worth well over a trillion US dollars a year and employs an estimated 60–75 million people worldwide, with many more in cotton farming and informal trade. It is a leading source of manufacturing jobs and export earnings across Asia, and a significant employer and consumer market in Europe, the Americas and Oceania. For many developing economies, textiles are the first rung on the industrial ladder.

The fast-fashion accelerator

What changed in the last two decades is not just how much we make, but how quickly we discard it. Global clothing production doubled between 2000 and 2015, while the average number of times a garment is worn before disposal fell sharply. “Fast fashion” — rapid, low-cost design cycles that turn trends into landfill in a matter of weeks — has driven both a surge in output and a collapse in useful garment lifetimes. The result is an industry producing an estimated 80–100 billion garments a year, many of which are barely worn.

The scale in perspective

~132 Mt of fibre produced in 2024 — four tonnes every second.

~59% of all fibre is polyester; ~88% of that is virgin fossil-based.

2x growth in clothing production between 2000 and 2015.

<1% of clothing is recycled back into new clothing.

The problem in one word: linear

The defining feature of today's textile system is that it is linear. Raw materials are extracted, spun and woven into products, sold, used briefly and thrown away. Value flows in one direction and is lost at the end. As the following chapters show, this linear design is the root cause of the industry's pollution and waste — and rethinking it is the heart of the circular solution.

CHAPTER TWO

Manufacturing Around the World

Textile manufacturing is a truly global enterprise, but it looks very different from one country to the next. To understand the sector's footprint, it helps to see where and how cloth is made — and what comes out of the factories alongside the fabric.

India: a manufacturing powerhouse

India is one of the world's largest textile producers and the **second-largest exporter of textiles and apparel**. The sector contributes around 2.3% of national GDP and a much larger share of manufacturing output, and it **directly employs more than 45 million people** — over 100 million including allied activities — making it India's second-biggest employer after agriculture. Textile and apparel exports were worth roughly US$37 billion in recent years, with government targets of US$100 billion by 2030.

India is also the world's largest cotton grower, accounting for roughly a quarter of global production, and the second-largest producer of polyester. Manufacturing is concentrated in dense industrial clusters: Tiruppur and Coimbatore (knitwear and spinning) in Tamil Nadu, Surat and Ahmedabad (synthetics and processing) in Gujarat, Ludhiana (woollens and knits) in Punjab, and Panipat (home textiles and recycling) in Haryana, among others. New integrated “PM MITRA” mega-parks aim to modernise the base further.

Europe: design, quality and regulation

The European Union hosts a substantial textile and clothing industry — tens of thousands of companies, most of them small and medium-sized, employing well over a million people — concentrated in Italy, Germany, France, Spain, Portugal and Eastern Europe. Europe specialises in higher-value segments: fashion design, technical and performance textiles, luxury goods and machinery. Much basic garment assembly, however, has moved to Asia and North Africa, so Europe is as much a consumer and importer as a producer. Crucially, Europe now leads the world in textile sustainability regulation, a theme we return to in Chapter 4.

Australia: a consumer economy

Australia has a modest domestic manufacturing base — wool growing (it is a leading exporter of raw wool), plus niche and technical textiles — but it is overwhelmingly a

consumer and importer of finished clothing. Australians are among the highest per-capita clothing buyers in the world, purchasing on the order of 55–56 new items each year. Around 1.5 billion units of new clothing enter the market annually, most of it imported and much of it synthetic. This consumption pattern, rather than factory pollution, is Australia's defining textile challenge.

United States: brands, cotton and consumption

The United States combines large-scale cotton and technical-textile production with the world's biggest apparel consumer market and many of its most powerful global brands. Domestic manufacturing is concentrated in yarn, industrial and technical textiles (notably in the south-eastern states), while most clothing is designed in the US and manufactured abroad. Like Australia, the US generates enormous volumes of post-consumer textile waste — a subject examined in Chapter 5.

Region	Role in the value chain	Defining feature
India	Major producer, exporter & cotton grower	45M+ jobs; dense manufacturing clusters
Europe	Design, technical & luxury; large importer	World-leading sustainability regulation
Australia	Wool exporter; mainly importer & consumer	Highest per-capita clothing consumption
USA	Cotton & technical textiles; global brands	Huge consumer market & post-use waste

Table 2.1 — How four regions sit within the global textile value chain.

The pollutants that leave the factory

Wherever cloth is dyed and finished, the same chemistry applies — and the same pollutants can result. Textile “wet processing” is water- and chemical-intensive: it is estimated that the industry consumes around 93 billion cubic metres of water a year and is responsible for roughly a fifth of global industrial water pollution from dyeing and finishing alone. More than 2,000 chemicals are used across textile processing.

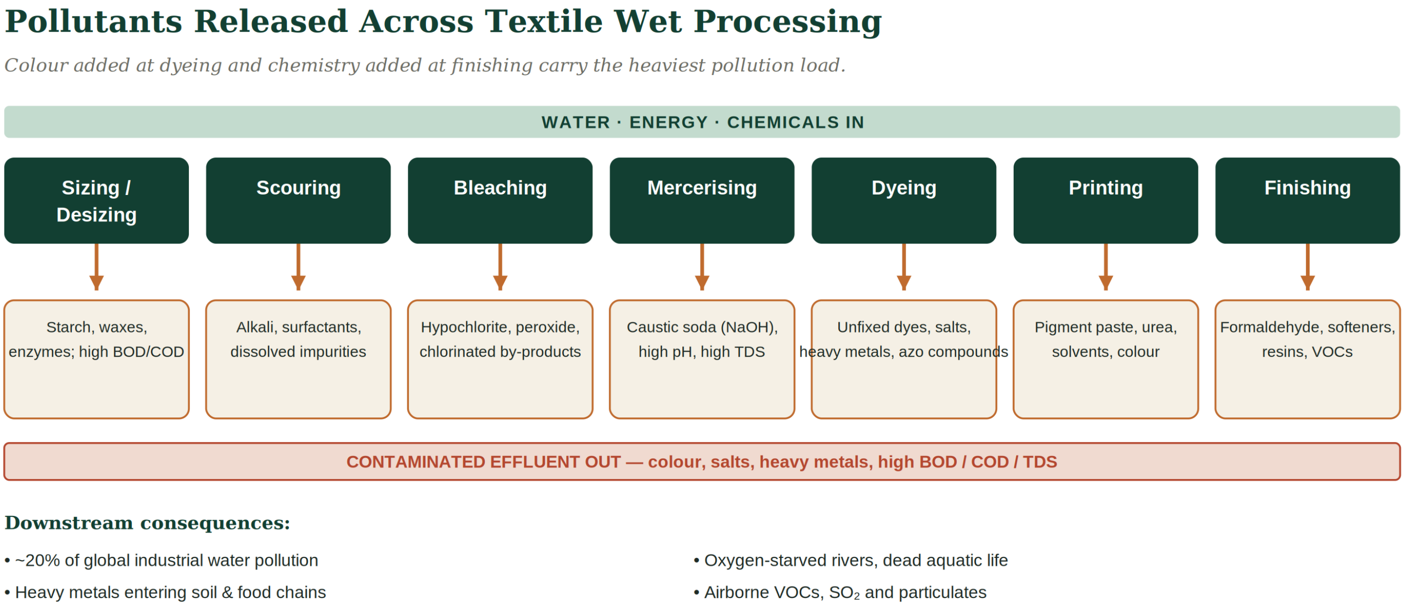


Figure 2.1 — Pollutants released across the main stages of textile wet processing.

Each processing step contributes its own load. **Sizing and desizing** release starches and enzymes that raise oxygen demand; **scouring and bleaching** add alkalis, surfactants and chlorinated compounds; **mercerising** produces highly alkaline, salty effluent; and **dyeing, printing and finishing** discharge unfixed dyes, salts, heavy metals (chromium, lead, cadmium, mercury, arsenic), azo compounds, formaldehyde and solvents. Roughly 20,000 tonnes of dye are lost to effluent worldwide each year.

Where this effluent is discharged untreated — a persistent problem in some manufacturing regions — it colours rivers, strips them of oxygen, kills aquatic life and carries carcinogenic and toxic compounds into soil, groundwater and the food chain. Airborne emissions add volatile organic compounds, sulphur dioxide and particulates. Beyond the factory, synthetic fabrics shed microplastic fibres throughout their life, from manufacture through every wash to final disposal.

Key manufacturing impacts

~93 billion m³ of water consumed by the sector each year.

~20% of global industrial water pollution comes from textile dyeing & finishing.

2,000+ chemicals used across textile processing; ~20,000 t of dye lost to effluent yearly.

~60% of clothing is synthetic — a continuous source of microplastic fibres.

CHAPTER THREE

The Lifecycle of a Textile

To manage textiles better, we first have to see the whole journey — from a boll of cotton or a barrel of oil, through the factory and the wardrobe, to the bin. Every stage carries an environmental cost, and every stage is a place where the loop can be closed.

Six stages from fibre to end-of-life

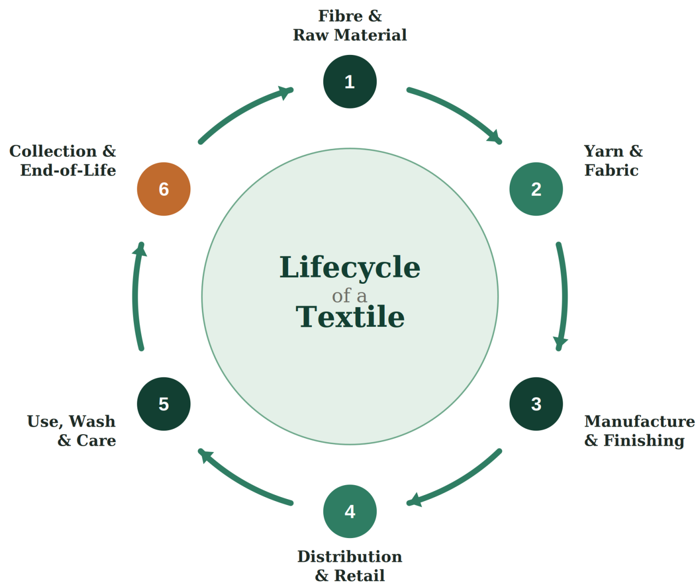


Figure 3.1 — The lifecycle of a textile, from raw material to end-of-life.

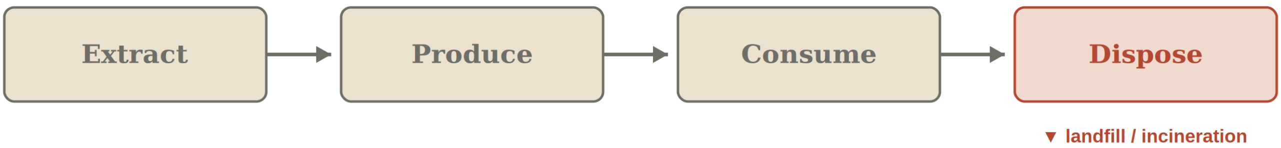
- **1. Fibre & raw material.** Growing cotton or other natural fibres, or extracting petrochemicals for synthetics. Heavy in land, water, energy and — for cotton — pesticides and fertilisers.
- **2. Yarn & fabric.** Spinning fibre into yarn and knitting or weaving it into cloth. Energy-intensive and, for wet steps, water-intensive.
- **3. Manufacture & finishing.** Dyeing, printing, finishing, cutting and sewing into products — the stage that generates most chemical pollution and off-cut waste.
- **4. Distribution & retail.** Packaging, freight and storage across global supply chains, with their own carbon and packaging footprint and frequent overproduction.

- **5. Use, wash & care.** Wearing, laundering and maintaining the product. Washing consumes water and energy and sheds microfibres; short use-phases waste all the impact already embedded.
- **6. Collection & end-of-life.** What happens when the item is no longer wanted — reuse, recycling, landfill or incineration. The decisive fork in the road.

Linear versus circular

The lifecycle above can run in two fundamentally different ways. In the linear model, the six stages form a straight line that ends in waste; all the water, energy, chemicals and labour embedded in the product are lost the moment it is discarded. In the circular model, the end of one life becomes the start of the next: products are designed to last, kept in use through reuse and repair, and — when they truly can no longer serve — broken back down into materials that re-enter production.

A. The Linear Model — “Take, Make, Waste”



Resources flow one way and value is lost at the end.

B. The Circular Model — Keep Materials in Use

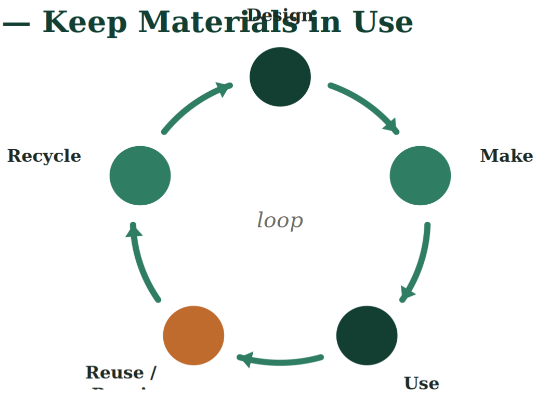


Figure 3.2 — The linear “take–make–waste” model versus a circular textile economy.

The distinction matters because most of a textile's environmental damage is “locked in” early, during fibre production and manufacturing. Every extra wear a garment gets, and every time a fibre is recovered instead of extracted afresh, spreads that embedded impact across more use and avoids a new round of extraction. Extending the active life of clothing is therefore one of the single most powerful levers available — which is exactly what circular strategies are designed to do.

CHAPTER FOUR

How Countries Manage the Waste

As the waste crisis has become impossible to ignore, governments have begun to act — but at very different speeds and in very different ways. The common thread in the most ambitious responses is a simple principle: make producers responsible for what they put on the market.

Extended Producer Responsibility, explained

The central policy tool is **Extended Producer Responsibility (EPR)**. Under EPR, the companies that place textiles on the market must fund — and often organise — the collection, sorting, reuse and recycling of those products at end-of-life, rather than leaving the cost to taxpayers and councils. Fees are increasingly "eco-modulated": lower for products that are durable, repairable, recyclable or made with recycled content, and higher for those that are not. In this way EPR is designed not just to pay for waste, but to reward better design.

Europe: the regulatory frontrunner

The European Union has moved furthest. France pioneered textile EPR back in 2007, operating through a producer-financed organisation now called Refashion, and reinforced it with its 2020 anti-waste "AGEC" law; the Netherlands and Latvia followed more recently. In October 2025 the EU's revised Waste Framework Directive entered into force, making textile EPR mandatory across all member states, which must establish national schemes by 2028. Separate textile collection has been required across the EU since January 2025. These rules sit alongside the EU Strategy for Sustainable and Circular Textiles, ecodesign requirements and forthcoming Digital Product Passports.

United States: states lead, no federal rule

The United States has no federal textile-waste law. Instead, individual states are moving. California's Responsible Textile Recovery Act (SB 707), signed in 2024, is the first statewide textile EPR programme in the country; producers must join a Producer Responsibility Organisation to fund collection, repair, recycling and reuse, and a PRO was selected in early 2026 to build the system. New York, Washington and Massachusetts are developing similar laws. The direction of travel is clear, even without national legislation.

Australia: an industry-led scheme

Australia has taken a different route with **Seamless**, the national clothing product-stewardship scheme that began operating on 1 July 2024. It is industry-led and, for now, voluntary: member brands contribute a small levy (initially four cents) on each new garment placed on the market, funding the design, collection, reuse and recycling needed to make Australian clothing circular by 2030. The government has signalled it will regulate if voluntary uptake proves insufficient.

India: reuse, repair and the informal economy

India's approach is less about formal EPR and more about a deep-rooted culture of reuse and repair, supported by a vast informal recycling economy. Cities such as Panipat have long turned discarded clothing — much of it imported from the West — into recycled yarn, blankets and industrial textiles. Tailoring, mending and hand-me-downs remain everyday practice. The challenge is to formalise, upgrade and scale this activity safely, and government initiatives increasingly promote upcycling and textile-waste valorisation.

Jurisdiction	Main mechanism	Status
European Union	Mandatory EPR + ecodesign	In force; national schemes by 2028
France	EPR via Refashion (since 2007)	Mature, eco-modulated
USA (California)	State EPR — SB 707	First US scheme; building out
Australia	Seamless product stewardship	Voluntary, live since 2024
India	Reuse, repair & informal recycling	Culturally embedded; scaling up

Table 4.1 — Contrasting national approaches to textile-waste management.

CHAPTER FIVE

The Waste Crisis at End-of-Life

For all this policy activity, the numbers at the end of the pipeline remain staggering. This chapter confronts what actually happens to textiles when we are finished with them — how much there is, where it goes, and how it harms the planet.

How much waste, and where it goes

The world generates on the order of **92 million tonnes of textile waste every year** — some recent estimates put the 2024 figure higher still — and this could reach 134 million tonnes or more by 2030 on current trends. Put another way, the equivalent of a garbage truck full of textiles is landfilled or burned **every second**. The largest national producers of textile waste are China (around 20 million tonnes) and the United States (around 17 million tonnes).

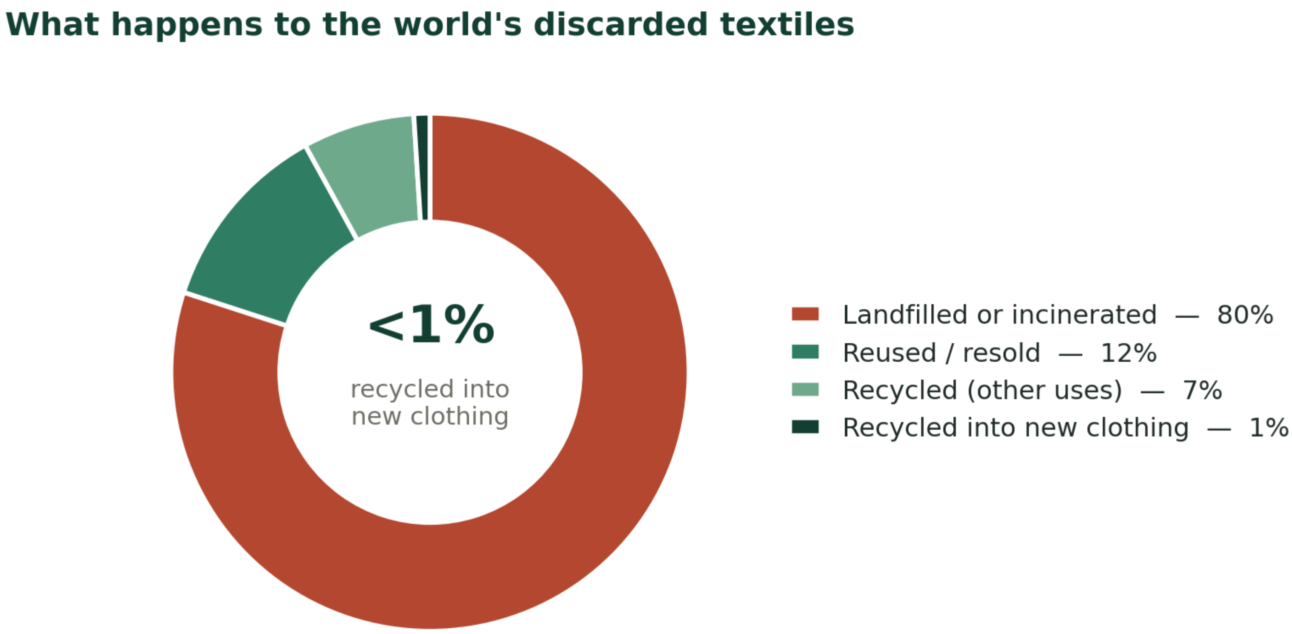


Figure 5.1 — The fate of the world's discarded textiles. Very little is genuinely recycled.

The destination of all this material is the heart of the problem. Globally, roughly **80% of discarded textiles are landfilled or incinerated**, around 12% are reused or resold, a further share is downcycled into low-grade uses such as insulation or rags, and **less than 1% is recycled back into new clothing**. Only about a fifth of textiles are even collected for reuse or recycling in the first place.

Consumption drives the pile

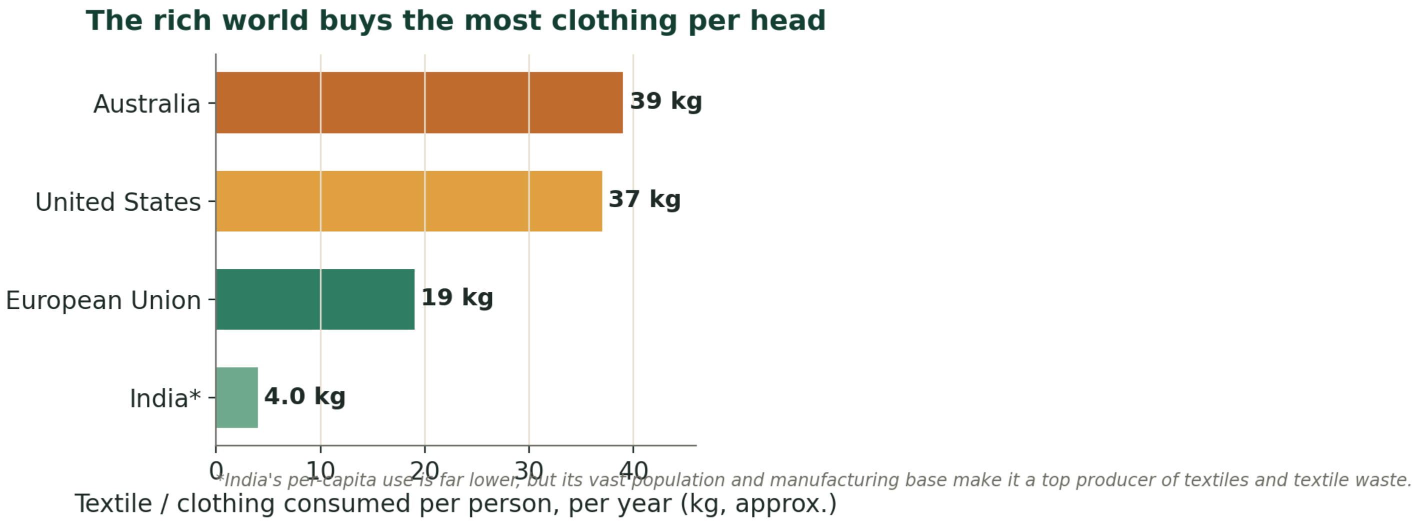


Figure 5.2 — Clothing consumed per person, per year, by region (approximate).

Waste is ultimately a function of consumption, and here the rich world leads. Australians and Americans each buy and dispose of the most clothing per head, while Europeans consume around 19 kilograms of textiles per person a year and discard roughly 11 kilograms of it. India's per-capita consumption is far lower, but its enormous population and manufacturing base still make it a major generator of textile waste in absolute terms.

Exporting the problem

Much of the clothing collected in wealthy countries does not stay there. Australia ships more than 100,000 tonnes of used textiles overseas each year, and Europe and North America export vast quantities of second-hand clothing to the Global South. A portion is genuinely reused, but a large share is unsellable and ends up dumped — piling into open-air markets and landfills such as Ghana's Kantamanto in Accra, or forming the notorious mounds of discarded fast fashion in Chile's Atacama Desert. Exporting textile waste is not recycling; it simply moves the harm somewhere with less power to refuse it.

How the waste harms the environment

- **Climate.** The fashion and textile sector is estimated to account for somewhere between 2% and 8% of global greenhouse-gas emissions — some studies place it near 10% — from energy-hungry production and rotting or burning waste.
- **Land & landfill.** Textiles occupy at least 7% of global landfill space and can take more than 200 years to break down; synthetics never fully biodegrade.
- **Water.** Beyond manufacturing pollution, decomposing and dumped textiles leach dyes and chemicals into soil and water.

- **Microplastics.** Synthetic garments shed plastic microfibres in every wash and in landfill, contaminating rivers, oceans, soils and — increasingly — the human body.
- **Toxics & health.** Burned textiles release toxic gases; dumped clothing contaminates communities that never consumed it.

The end-of-life numbers

~92 Mt of textile waste generated worldwide each year — a truckload every second.

~80% of discarded textiles are landfilled or incinerated.

<1% is recycled into new clothing; only ~20% is even collected.

>200 years for some textiles to decompose in landfill.

CHAPTER SIX

Treating Textile Waste

If less than one per cent of clothing becomes new clothing, the obvious question is: what can actually be done with all this material? The answer is a hierarchy of options — some old, some newly industrialising — that together can divert the mountain of textile waste from landfill.

Follow the waste hierarchy

The guiding principle is the waste hierarchy: prevent first, then reuse, then recycle, and only then recover energy, with disposal as the last resort. Applied to textiles, this means the best "treatment" is often not to create the waste at all — but where waste does exist, the goal is to keep it at the highest possible value for as long as possible.

Collection and sorting

Nothing can be reused or recycled unless it is first collected and sorted. Efficient, convenient collection — kerbside, in-store take-back, drop-off points and mail-back programmes — is the essential front end. Sorting, increasingly aided by automated fibre-identification technology, separates items into reusable clothing, recycling feedstock by fibre type, and residual waste. Better sorting directly determines how much value can be recovered downstream.

Reuse and repair

The highest-value routes keep a garment as a garment. Reuse — through charity shops, resale platforms and second-hand markets — is already the largest and fastest-growing form of textile diversion, and resale is expanding several times faster than conventional retail. Repair and refurbishment extend life further and are gaining cultural momentum, supported by brands offering mending services and "buy-back" programmes.

Recycling: mechanical, chemical, biological

Mechanical recycling shreds textiles and re-cards the fibres into new yarn. It is mature and low-energy, but shortens and weakens fibres and works best on clean, single-fibre inputs, so output is often downcycled. **Chemical recycling** dissolves or depolymerises textiles back to their molecular building blocks, producing regenerated fibres close to virgin quality and — critically — able to handle blended fabrics. It is more energy- and capital-intensive, but the first commercial-scale textile-to-textile plants are now being built. **Biological (enzymatic) recycling**, still emerging, uses enzymes to break fibres down selectively and at lower temperatures.

> **The recycling bottleneck**
>
> Today's recyclers struggle with the reality of what we make: most garments are fibre blends, coated with dyes and finishes, and full of zips, buttons and elastane.
>
> Because recycling is highly sensitive to feedstock purity, the single biggest lever is upstream: **designing garments to be recyclable in the first place** — mono-materials, easy disassembly and cleaner chemistry.

Energy recovery and disposal

When textiles genuinely cannot be reused or recycled — heavily soiled, contaminated or degraded material — energy recovery through controlled incineration captures some value and avoids landfill, though it destroys the material permanently and must be tightly managed for emissions. Landfill remains the true last resort. The strategic aim of every option above is to shrink this residual fraction toward zero.

CHAPTER SEVEN

The Circular Economy

The treatments in the previous chapter are necessary but not sufficient. Recycling a linear system more efficiently still leaves it linear. The circular economy asks a deeper question: how do we redesign the whole system so that waste and pollution are engineered out from the start?

What "circular" really means

A circular economy rests on three principles: eliminate waste and pollution by design; keep products and materials in use at their highest value; and regenerate natural systems. It is not simply "recycling more." Recycling is the outermost, lowest-value loop — a fallback for when everything else has failed. The tighter, more valuable loops — maintaining, reusing, repairing and remanufacturing — keep products whole and working for longer, and should always come first.

The ladder of value retention

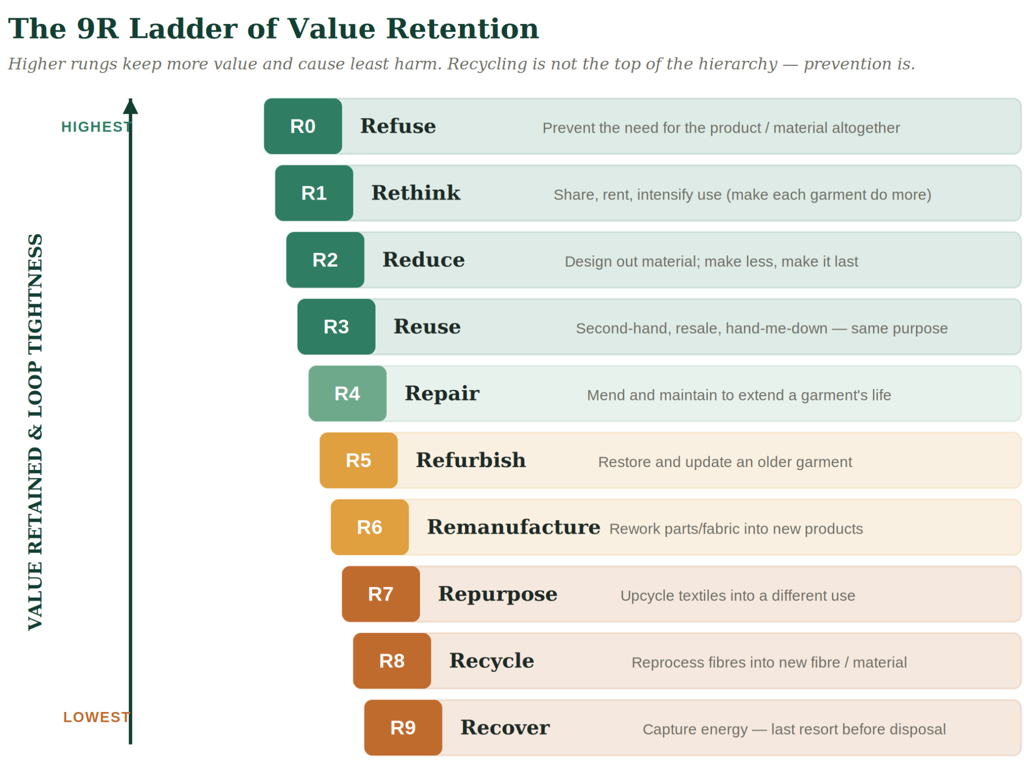


Figure 7.1 — The 9R ladder: circular strategies ranked from highest to lowest value retention.

The so-called 9R framework arranges circular strategies from most to least valuable. At the top, Refuse and Rethink question whether a product is needed at all, or whether its use can be shared and intensified. Reduce, Reuse and Repair keep existing products in service. Refurbish, Remanufacture and Repurpose rework products and components. Only near the bottom do Recycle and Recover appear — useful, but a sign that the tighter loops above have run out. The higher a strategy sits, the more embedded value and impact it preserves.

Where circularity applies

The crucial insight for textiles is that circularity is not a single intervention bolted on at the end. It applies at every stage of the lifecycle we traced in Chapter 3 — in how products are designed, what they are made from, how they are manufactured, sold, used and finally recovered. A garment designed for durability and recycling, made from a single recyclable fibre, produced with clean chemistry, sold through a model that encourages long use, and collected for fibre recovery at the end, closes the loop many times over. The next chapter shows exactly how to build circularity into each of those stages.

Circular in one sentence

Design out waste, keep materials in use at their highest value, and regenerate nature — **so that the end of one textile's life becomes the beginning of the next.**

CHAPTER EIGHT

Implementing Circularity, Stage by Stage

This is where principle becomes practice. Below is a map of the circular "modes" that can be built into each stage of the textile value chain, followed by a closer look at each — and the business models and enablers that make them work.

A map of interventions at every stage

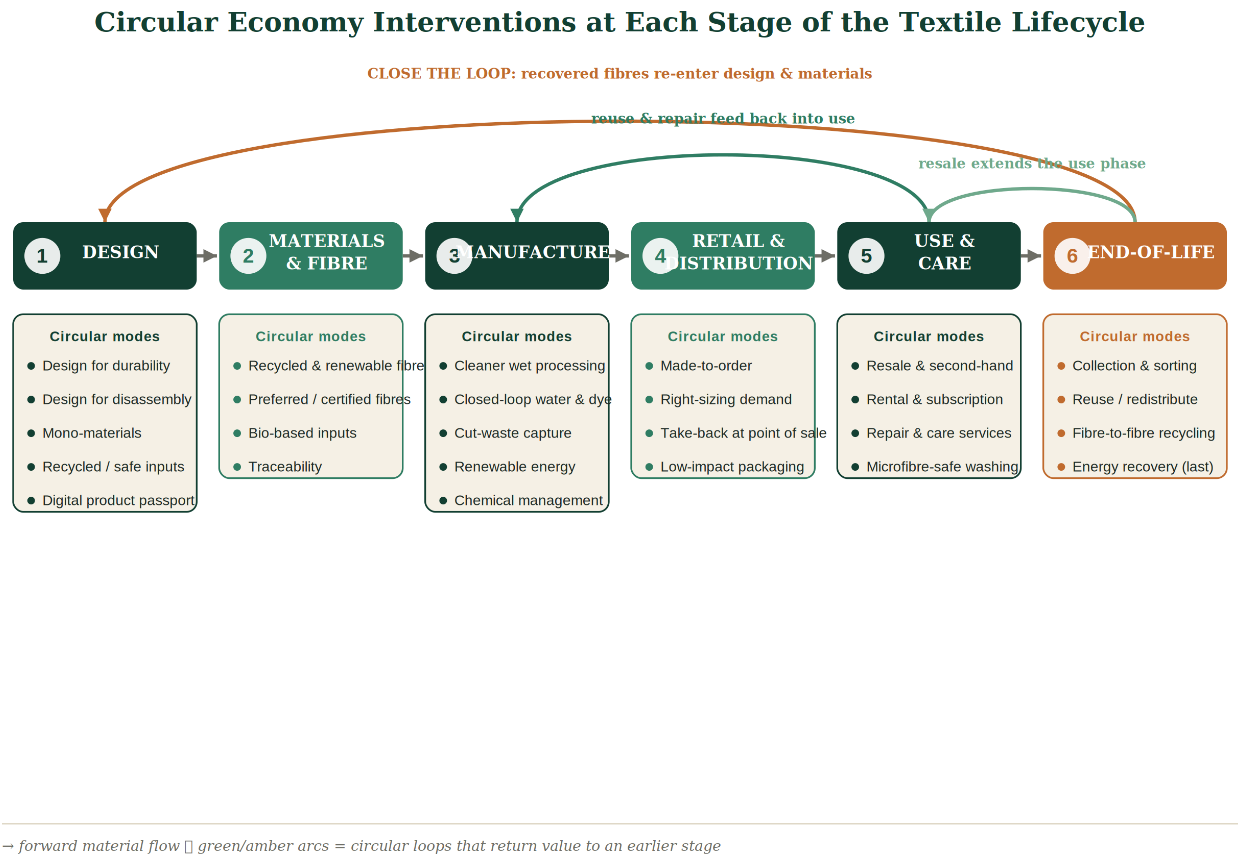


Figure 8.1 — Circular economy interventions at each stage of the textile lifecycle. Forward arrows show material flow; the curved arrows show circular loops that return value to an earlier stage.

Stage by stage

1. Design — where 80% of impact is decided

Most of a garment's environmental fate is locked in at the drawing board. Circular design means durability (so products last), design for disassembly (so they can be taken apart), a preference for mono-materials and safe, recycled inputs (so they can be recycled), and traceability — increasingly via a Digital Product Passport that records what a product is made of and how to recover it.

2. Materials & fibre — choose inputs that can loop

Circularity favours recycled and renewable fibres, certified and preferred materials, and bio-based inputs, all underpinned by traceability so recyclers know what they are handling. Shifting away from virgin fossil-based synthetics toward recyclable and lower-impact fibres widens the options at every later stage.

3. Manufacture — make it clean and keep the offcuts

At the factory, circular practice means cleaner wet processing, closed-loop water and dye systems that recover and reuse inputs, capture of cutting-room offcuts (which can be a sixth of the fabric), renewable energy, and rigorous chemical management to keep hazardous substances out of both product and effluent.

4. Retail & distribution — sell smarter, not just more

Overproduction is itself a form of waste. Made-to-order and demand-led production, better forecasting, low-impact packaging, and take-back at the point of sale all reduce the volume that ends up unsold or discarded, while bringing used products back into the system.

5. Use & care — the longest, most powerful loop

Extending the use phase delivers the biggest returns, and it is where new business models concentrate: **resale and second-hand**, **rental and subscription**, and **repair and care services**. Encouraging microfibre-safe washing (cooler, fuller loads and filtration) reduces pollution during use. Every additional wear spreads a garment's embedded impact and delays the need to make another.

6. End-of-life — close the loop

Finally, robust collection and sorting feed reuse and redistribution first, then fibre-to-fibre recycling, with energy recovery only as a last resort before disposal. Done well, this stage returns materials to the start of the chain — the loop closing arrows in Figure 8.1 — so that recovered fibre re-enters design and materials rather than the landfill.

Business models that make it pay

- **Resale & second-hand.** Platforms and in-house resale turn used garments into revenue and keep them in use.
- **Rental & subscription.** Access over ownership for occasion-wear, workwear and children's clothing, maximising wears per item.
- **Repair & maintenance services.** Mending, alterations and refurbishment as a paid service and a driver of brand loyalty.
- **Take-back & buy-back.** Bringing products back for reuse or recycling, often rewarded with credit.
- **Recycled-content & product-as-a-service.** Building demand for recovered fibre and shifting revenue from volume to value.

The enablers that unlock it

None of these modes scales in isolation. They depend on a set of enablers: supportive policy (EPR, ecodesign, collection mandates); traceability and Digital Product Passports; investment in collection, sorting and recycling infrastructure; standards and eco-modulated incentives that reward good design; access to finance for circular businesses; and, not least, consumers who value durability, repair and reuse over disposability.

Lifecycle stage	Priority circular modes
Design	Durability, disassembly, mono-materials, product passports
Materials	Recycled & renewable fibres, certification, traceability
Manufacture	Closed-loop water & dye, offcut capture, clean energy
Retail	Made-to-order, take-back, low-impact packaging
Use	Resale, rental, repair, microfibre-safe care
End-of-life	Collect, sort, reuse, fibre-to-fibre recycling

Table 8.1 — Priority circular “modes” to implement at each stage of the value chain.

CHAPTER NINE

A Roadmap to Circular Textiles

Closing the loop on textiles is not the work of any single actor. It needs governments, businesses and citizens to pull in the same direction — each with a distinct and achievable role.

For governments and regulators

- Adopt or strengthen Extended Producer Responsibility, with eco-modulated fees that reward durable, recyclable design.
- Mandate separate collection and set binding reuse and recycling targets.
- Invest in collection, sorting and recycling infrastructure, and require traceability such as Digital Product Passports.
- Restrict the export of unsorted textile waste, so the problem is solved rather than relocated.

For brands and manufacturers

- Design for longevity, repairability and recyclability — treat design as the primary lever.
- Move to recycled and preferred fibres, and clean, closed-loop manufacturing.
- Build resale, rental, repair and take-back into the core business model, not the margins.
- Slow production, reduce overstock, and measure success by value and use, not volume.

For consumers and citizens

- Buy less and buy better; choose quality, durability and, where possible, recycled or second-hand.
- Wear garments longer, wash them cooler and fuller, and repair rather than replace.
- Resell, donate or return clothing responsibly, and support brands with genuine circular practices.

The opportunity

The circular economy is often framed as a constraint. It is better understood as an opportunity — commercial, environmental and social. The market for circular textiles is already growing quickly and is expected to more than double over the coming decade. Every tonne of fibre kept in use is a tonne that need not be extracted, dyed, shipped and dumped. The technologies, business models and policies now exist; what remains is the will to connect them into a system.

Textiles have clothed humanity for thousands of years by turning raw material into something useful and beautiful. The task of this generation is to make sure that when a textile's first life ends, its story does not — but instead loops back to the beginning.

SECTION TWO

A Global Catalogue of Fabrics

No one knows exactly how many textile fibres exist — the number runs well into the hundreds once regional, blended and newly invented materials are counted. This catalogue surveys the most important, grouped into five families, so the diversity of the world's cloth can be seen at a glance.

For each fabric, four things are noted: its quality and character; how it is made; what it is used for; and where it is predominantly grown or produced. Together they show why no single circular solution can fit them all — the theme of Section Three.

The five fabric families

Natural plant fibres — from cotton and linen to banana, pineapple and cactus.

Natural animal fibres — wool, silk, cashmere and other protein fibres.

Regenerated cellulosics — viscose, modal and lyocell, made from wood and waste.

Synthetic fibres — polyester, nylon and the other petroleum-based plastics.

Next-generation bio-materials — leathers and fibres grown from food and farm waste.

Natural plant (cellulosic) fibres

Cotton

The world's most widely used natural fibre, cotton is soft, breathable, absorbent and comfortable against the skin, though it creases easily and weakens when wet. It grows as fluffy bolls on the cotton plant, which are ginned to separate seed from fibre, then carded and spun into yarn. Cotton clothes almost every wardrobe — t-shirts, shirts, underwear, denim, towels and bedding. It is cultivated across the tropical and subtropical belt, with India, China, the United States, Brazil and Pakistan the leading producers; India has the largest area under cultivation.

Organic cotton

Chemically identical to conventional cotton but valued for a far lower environmental and health footprint, organic cotton is grown from non-GM seed without synthetic pesticides or fertilisers. It is farmed and spun like ordinary cotton but under certified standards such as GOTS. It appears across apparel and home textiles from sustainability-minded brands. India leads world production, followed by parts of Africa, Turkey and China, though organic still accounts for only a small share of the cotton crop.

Linen (flax)

Made from the stalks of the flax plant, linen is strong, cool, highly absorbent and grows softer with every wash, though it wrinkles readily. The stems are retted (soaked to loosen the fibres), scutched and combed before spinning. Linen is the classic summer cloth — shirts, dresses, trousers and jackets — and a staple of fine bedding, tablecloths and towels. The best flax grows in a cool coastal band of Western Europe, especially France, Belgium and the Netherlands, with much spinning now done in Eastern Europe and Asia.

Hemp

One of the strongest and most durable natural fibres, hemp naturally resists mould and ultraviolet light; it feels coarse at first but softens with use. It is a bast fibre stripped from the stalks of the Cannabis sativa plant, retted and separated much like linen. Long used for rope, sailcloth, canvas and sacking, it now features in hard-wearing apparel, bags and cotton blends. China dominates world production, with growing cultivation in Europe (notably France), Canada and the United States.

Jute

Known as the “golden fibre,” jute is inexpensive, strong in bulk and fully biodegradable, but coarse and quick to weaken in moisture and sunlight. It is a bast fibre retted and stripped from the jute plant's stalks. Its main uses are sacking, hessian (burlap), rope, twine and carpet backing, and increasingly eco-friendly bags and geotextiles. Almost the entire world crop comes from the Ganges–Brahmaputra delta, with India and Bangladesh the overwhelming producers.

Ramie

Ramie is exceptionally strong with a silky lustre and natural resistance to bacteria and stains, but it is stiff, brittle and creases easily, so it is usually blended. It is drawn from the stalks of a nettle-family plant and needs labour-intensive de-gumming to yield usable fibre. It goes into blended apparel, handkerchiefs, upholstery, ropes and nets. China is by far the largest producer, followed by Brazil, the Philippines and India.

Banana / Abacá

Banana fibre is strong, lightweight, lustrous, buoyant and biodegradable, ranging from coarse outer fibres to fine, silk-like inner ones. It is extracted from the banana plant's pseudo-stem — or from the leaf sheaths of its relative abacá (Manila hemp) — then cleaned, dried and spun. Uses run from ropes, mats and specialty papers (banknotes, tea bags) to scarves, sarees and upholstery. Abacá comes chiefly from the Philippines and Ecuador, while banana-stem textiles are developing in India, Nepal, East Africa and Japan.

Pineapple (Piña)

Piña is a fine, lightweight, naturally lustrous fibre — stiff and delicate — that yields a crisp, almost translucent cloth. It is hand-scraped from the long leaves of the pineapple plant, then knotted and woven in a slow, artisanal process. Traditionally it makes the Philippines' ceremonial Barong Tagalog and formal wear, and its leaf waste now feeds the leather alternative Piñatex. It is produced predominantly in the Philippines, particularly Aklan province.

Bamboo

Bamboo cloth is soft, drapey, breathable and widely marketed as antibacterial. Crucially, most "bamboo" fabric is really bamboo viscose — the plant is dissolved in strong chemicals and regenerated as rayon — while true, mechanically processed bamboo linen is rare and coarser. It is used for t-shirts, underwear, socks, towels and bedding. Cultivation and, overwhelmingly, chemical processing are concentrated in China.

Coir

Coir is a very coarse, stiff and highly durable fibre that resists rot and saltwater. It is extracted from the fibrous husk of coconuts, retted and beaten free of pith. Too rough for clothing, it becomes doormats, brushes, ropes, mattress and upholstery filling, and erosion-control matting. India (especially Kerala) and Sri Lanka produce almost all of the world's coir.

Kapok

Kapok is extraordinarily light, buoyant, water-repellent and silky, but too short and slippery to spin easily alone. It is the fluffy floss around the seeds of the kapok tree, simply harvested and cleaned. It has long stuffed pillows, mattresses, soft toys and life-jackets, served as insulation, and now appears in blended yarns. It grows across the tropics, with Indonesia and South-East Asia the main sources.

Sisal

Sisal is a stiff, strong, coarse fibre valued for durability rather than comfort. It is extracted from the sword-shaped leaves of the agave plant by crushing and scraping. It is used for rope, agricultural twine, rugs, matting, dartboards and, increasingly, composites and plaster reinforcement. Brazil is the largest producer, alongside Tanzania, Kenya, Mexico and Madagascar.

Nettle (Himalayan allo)

Nettle fibre is strong and linen-like, with a soft sheen and good insulating properties. It is a bast fibre harvested from the stalks of the wild Himalayan nettle (allo) or common nettle, hand-stripped and processed much like hemp. It is woven into shawls, bags, jackets and traditional textiles, and is enjoying a revival among sustainable brands. It is produced in the hills of Nepal and India, and on a small scale across Europe.

Lotus

Lotus fibre is among the rarest and costliest of textiles — light, soft, breathable and naturally water- and stain-resistant, with a linen-like feel. It is drawn by hand from the sticky threads inside lotus stems and spun within hours, taking tens of thousands of stems for a single scarf. It is reserved for luxury scarves, robes and sacred garments. Production centres on Myanmar's Inle Lake, with smaller output in Cambodia and Vietnam.

Natural animal (protein) fibres

Silk (mulberry)

Silk is lustrous, smooth, remarkably strong for its weight and thermoregulating, but delicate and sensitive to sunlight and perspiration. It is unwound as a continuous filament from the cocoons of the mulberry silkworm — a practice called sericulture — then reeled and woven. It is the classic luxury cloth of scarves, ties, blouses, eveningwear, lingerie and fine furnishings. China is the dominant producer, followed by India; both hold ancient silk traditions.

Wild & peace (Ahimsa) silk

Wild silks such as tussar, eri and muga are coarser, more textured and more golden than mulberry silk, while “peace” (ahimsa) silk is reeled only after the moth has left the cocoon, sparing the pupa. They come from semi-wild silkworms feeding on forest trees. They are used for shawls, sarees, jackets and ethically marketed apparel. India — especially its eastern and north-eastern states — and China are the principal sources.

Wool (sheep, incl. Merino)

Wool is warm, resilient, elastic, naturally moisture-wicking and flame-resistant, though some grades itch and it can shrink or felt if mishandled. It is shorn from sheep, then scoured, carded and spun; fine Merino gives the softest next-to-skin wool. It is used for knitwear, suiting, coats, carpets, felt and, increasingly, performance activewear. Australia is the leading producer of fine apparel (Merino) wool, with China the largest overall and New Zealand strong in coarser wools.

Cashmere

Cashmere is ultra-soft, exceptionally warm for its weight and light, but delicate, prone to pilling and costly. It is the fine downy undercoat of cashmere goats, combed out by hand each spring and dehaired. It is reserved for luxury sweaters, scarves, shawls and coats. China and Mongolia (including Inner Mongolia) supply the great majority of the world's cashmere.

Mohair

Mohair is lustrous, springy, durable and takes dye brilliantly, giving a characteristic sheen and fuzzy halo. It is shorn twice a year from the Angora goat. It is used in suiting, upholstery, throws, scarves and fine knitwear, often blended with wool. South Africa is by far the largest producer, followed by the United States (Texas) and Turkey.

Alpaca

Alpaca fibre is soft, silky, hollow-cored and therefore very warm, hypoallergenic and free of the lanolin found in sheep's wool. It is shorn annually and comes in a wide range of natural colours. It is used for luxury knitwear, coats, blankets and accessories. Peru produces the overwhelming majority, high in the Andes, with Bolivia and a growing global herd also contributing.

Angora

Angora is extraordinarily soft, fluffy and warm, with a fine halo, but it sheds, mats easily and is usually blended for strength. It is the fur of the Angora rabbit, gathered by combing, shearing or plucking. It is used in luxury knitwear and accessories, typically as a small part of a blend. China produces most of the world's angora, though welfare concerns have curbed its use by many brands.

Camel hair

Camel hair is soft, light and highly insulating, with a warm golden-brown colour. The prized fibre is the fine undercoat of the Bactrian camel, collected as it is naturally shed and separated from the coarser outer hair. It is used for premium overcoats, jackets, blankets and knitwear. It comes chiefly from Mongolia, China and across Central Asia.

Yak wool

Yak down is soft, warm and comparable to cashmere, with good breathability and a low-impact, sustainable reputation. It is combed from the undercoat of domesticated yaks and dehaired. It is used for knitwear, scarves and, increasingly, outdoor and sustainable brands. It is produced on the Tibetan plateau, in Mongolia, Nepal and other high-altitude parts of Central Asia.

Regenerated (man-made cellulosic) fibres

Viscose / Rayon

Viscose is soft, fluid, breathable and absorbent with a silk-like drape, but it weakens when wet and can shrink. Though made from a natural raw material — wood pulp — it is semi-synthetic: the pulp is dissolved in strong chemicals and extruded as filaments, a process that pollutes heavily if uncontrolled. It is used for dresses, blouses, linings and blends. Production is concentrated in China, India and Indonesia.

Modal

Modal is a refined viscose that is softer, stronger (especially wet) and more resistant to shrinkage and fading. It is made from beech-wood pulp using a modified, higher-tenacity spinning process. It is favoured for underwear, loungewear, activewear, t-shirts and bedding. The fibre technology originates with Lenzing of Austria, while most spinning and garment-making is in Asia.

Lyocell (TENCEL)

Lyocell is soft, strong both wet and dry, breathable, gentle on skin and biodegradable. It is made from wood pulp dissolved in a non-toxic solvent recycled in a near closed-loop system, making it one of the more environmentally sound man-made fibres. It is used in denim, shirting, dresses, activewear and bedding, often under the TENCEL brand. It was pioneered by Lenzing (Austria), with plants in Europe, the Americas and Asia.

Cupro

Cupro is smooth, silky, breathable and drapey, often marketed as a vegan silk. It is regenerated from cotton linter — the short fuzz left on cotton seeds after ginning — dissolved in a copper-ammonia solution. It is used for luxurious linings, blouses and flowing garments. Its principal producer is Asahi Kasei of Japan, under the Bemberg name.

Acetate

Acetate is glossy, silky and drapes beautifully, but it is weak, heat-sensitive and dissolves in some solvents. It is made by treating cellulose (wood pulp or cotton linter) with acetic acid to form cellulose acetate, then extruding it. It is used for eveningwear, linings, ribbons and filters. It is produced across Asia, Europe and North America.

SeaCell

SeaCell is a soft, skin-friendly fibre that incorporates seaweed said to release beneficial minerals. It is made by embedding dried, ground seaweed into the closed-loop lyocell process. It is used in wellness apparel, activewear, underwear and bedding, usually blended with lyocell or cotton. It is manufactured in Germany.

Synthetic (petroleum-based) fibres

Polyester

Polyester is the world's most-produced fibre — strong, durable, wrinkle- and shrink-resistant, quick-drying and cheap — but it breathes poorly and sheds plastic microfibres. It is a plastic (PET) made from petroleum and melt-spun into filaments. It goes into virtually everything: fashion, sportswear, home textiles, upholstery and technical fabrics, alone or in blends. China dominates production, which now supplies well over half of all fibre made on Earth.

Recycled polyester (rPET)

Recycled polyester performs almost identically to virgin polyester while cutting fossil-resource use and diverting waste. It is made mainly by cleaning, chipping and re-melting used PET bottles — and, increasingly, textile waste — into new fibre. It is widely used in activewear, outerwear, bags and sustainability-marketed fashion. China leads production, with capacity growing worldwide.

Nylon (polyamide)

Nylon is exceptionally strong, elastic, abrasion-resistant and quick-drying, but non-breathable and, like all synthetics, fossil-derived and slow to degrade. It is a polyamide made from petrochemicals and melt-spun. It is used for hosiery, swimwear, activewear, lingerie, outerwear shells, backpacks and industrial textiles. It is produced globally, with major capacity in China and across Asia.

Recycled nylon (ECONYL)

Recycled nylon matches virgin nylon in performance and can, in principle, be recycled repeatedly. It is regenerated from nylon waste — discarded fishing nets, carpet and fabric scraps — which are depolymerised and re-spun. It is popular for swimwear, activewear and hosiery. The best-known brand, ECONYL, is produced by Aquafil in Italy.

Acrylic

Acrylic is soft, warm and wool-like at low cost, but it pills, holds odour, breathes poorly and sheds microplastics heavily. It is spun from acrylonitrile, a petroleum derivative. It is used for cheap knitwear, sweaters, hats, scarves, blankets, faux fur and fleece. It is produced worldwide, with much capacity in Asia.

Elastane (spandex / Lycra)

Elastane provides extraordinary stretch and recovery, snapping back to shape after being stretched several times its length. It is a polyurethane-based fibre made by chemical (dry) spinning. It is almost never used alone but blended in small amounts into denim, activewear, hosiery, underwear and swimwear to add stretch. Produced globally under names such as Lycra and Spandex, it contaminates other fibres and is a major obstacle to recycling.

Polypropylene

Polypropylene is the lightest common fibre — it floats — and is water-repellent, quick-drying, chemically resistant and inexpensive, though it melts at low temperatures. It is melt-spun from propylene gas. It is used in thermal base layers, sportswear, disposable and medical nonwovens, carpets, geotextiles and packaging. It is produced worldwide.

Blends & part-plastic fabrics

Most modern garments are not one fibre but a blend — poly-cotton shirts, cotton-elastane jeans, wool-nylon knits — engineered to combine easy care, comfort, stretch and low cost. They are made by mixing fibres during spinning or combining yarns in weaving and knitting. They dominate everyday clothing, uniforms, bedding and workwear. Made everywhere, blends are the single biggest technical barrier to textile recycling, because their fibres are so hard to separate.

Next-generation & bio-based materials

Piñatex (pineapple leather)

Piñatex is a flexible, leather-like non-woven with a natural texture — lighter than leather but usually finished with a petroleum-based coating. It is made from pineapple-leaf fibres, an agricultural waste product, bonded with a corn-based bioplastic (PLA) and a resin finish. It is used for shoes, bags, wallets, upholstery and accessories as a leather alternative. The fibre is sourced largely from the Philippines and the material is developed by Ananas Anam of the UK.

Cactus leather (Desserto)

Cactus leather is a soft, durable, partly bio-based leather alternative. It is made from the mature pads of the nopal (prickly-pear) cactus, which are harvested without killing the plant, then dried, milled and combined with binders. It is used in fashion accessories, footwear, upholstery and even car interiors. It is produced in Mexico, in the state of Zacatecas, under the Desserto brand.

Mushroom leather (mycelium)

Mycelium leather is a supple, biodegradable leather alternative that is grown rather than farmed. It is produced by cultivating the root-like network of fungi (mycelium) on agricultural substrate, then compressing and finishing it into sheets. It is used by luxury and sportswear brands for bags, shoes and accessories. Leading developers include Bolt Threads (Mylo), Ecovative and MycoWorks in the United States.

Orange Fiber

Orange Fiber is a soft, silky cellulosic fabric with a light, lustrous drape. It is made from the pastazzo — the pulp and peel left over from industrial citrus-juice production — which is turned into cellulose and spun, often blended with other fibres. It is used for scarves, dresses and luxury fashion. It is produced in Italy, using Sicilian citrus waste.

Grape leather (Vegea)

Vegea, or "wine leather," is a leather-like material with a partly bio-based content. It is made from grape marc — the skins, stalks and seeds left after wine-making — combined with plant oils and other binders. It is used for accessories, footwear, upholstery and packaging. It is produced in Italy from the by-products of the wine industry.

Apple leather

Apple leather is a leather alternative with a soft handfeel and partly bio-based make-up. It is produced by drying and milling apple pomace — the skins and cores left from juice and cider — and blending it with polyurethane on a textile backing. It is used for bags, shoes, wallets and book covers. It is made mainly in Italy, using apple waste from the Alpine fruit industry.

Milk fibre (casein / QMilk)

Milk, or casein, fibre is soft, smooth, silk-like and naturally antibacterial. It is made by extracting the protein casein from surplus or waste milk and spinning it into filaments; the modern QMilk process uses only water and heat. It is used in soft apparel, underwear and blends. It is produced in small quantities, notably in Germany.

Soy fabric

Soy fabric, sometimes called "vegetable cashmere," is soft, warm, drapey and lustrous. It is made from the protein left over from soybean processing (tofu and oil production), which is liquefied and extruded into fibre. It is used in soft t-shirts, underwear, loungewear and blends. It is produced mainly in China.

Brewed protein fibres

Engineered protein fibres aim to reproduce the strength and softness of silk or wool without animals. They are produced by fermenting sugars with microbes to “brew” protein, which is then spun into fibre — a process pioneered for lab-grown, spider-silk-inspired materials. They are being adopted by outdoor and luxury brands for premium apparel. The best-known, Brewed Protein, is made by Spiber in Japan.

Recycled cotton

Recycled cotton eases the water, land and pesticide burden of virgin cotton, but its shredded fibres are shorter and weaker, so it is usually blended. It is made by mechanically shredding cotton offcuts and worn textiles back into fibre. It is used in denim, t-shirts, insulation, cleaning cloths and blended yarns. Long-standing recycling hubs include Panipat in India, alongside a fast-growing global recycling industry.

SECTION THREE

Circular Economy Models, Fabric by Fabric

Circularity is not one-size-fits-all. A fabric's best circular model depends on whether it is renewable, whether it biodegrades, whether it can be recycled — and how easily it can be separated from other fibres. This section sets out a circular model for each family of fabric, then distils them into a single quick-reference table.

> **The golden rule, in one line**
>
> **Keep natural fibres pure and compostable; keep synthetics circulating in closed technical loops; and design blends out wherever you can.**

Natural plant fibres

These fibres are renewable and, if pure, biodegradable, so their ideal loop keeps them in use for as long as possible and then returns them safely to the soil. The model runs: grow regeneratively (organic, low-chemical farming that rebuilds soil and stores carbon); design durable, repairable, mono-material products; maximise reuse and resale; mechanically recycle worn textiles into new yarn or lower-grade goods such as insulation, wadding and wipers; and finally compost genuinely pure, undyed items. The two great enemies of this loop are blending with synthetics or elastane — which blocks both recycling and composting — and heavy chemical dyeing and finishing, which can leave “natural” cloth neither recyclable nor safely compostable. Agri-residue fibres such as banana, pineapple and coir are circular by origin, since they turn crop waste that would otherwise be burned into useful material.

Natural animal fibres

Animal fibres are renewable, biodegradable and — crucially — high in value and emotional durability, which makes long use their strongest circular lever. The model is: source with high animal welfare and land stewardship (rotational grazing can even sequester carbon); design timeless, durable, repairable pieces; sustain a vigorous second-hand, vintage and repair market, since wool and cashmere hold value for decades; re-spin recovered wool into “recycled wool,” as the historic mills of Prato in Italy have done for generations; and biodegrade pure items at the very end. Because these fibres are premium and finite, keeping each garment in service for many years — through repair, careful storage and resale — matters more here than any recycling technology.

Regenerated cellulosics

Viscose, modal, lyocell and cupro can be circular at both ends — in their feedstock and their biodegradability — provided the chemistry is clean. The model is: source wood from certified, regenerated forests, or better still make the fibre from waste (recycled cotton, textile pulp or agricultural residue, as newer "circular" cellulosics do); use closed-loop, low-emission processes such as the lyocell solvent system; design pure, biodegradable garments; reuse and resell; and, at true end of life, either chemically recycle the cellulose or compost it. The priority intervention is upstream — shifting from polluting, virgin-wood viscose to closed-loop and waste-fed cellulosics, and keeping these fibres out of synthetic blends so they stay compostable.

Synthetic (petroleum-based) fibres

Synthetics are neither renewable nor biodegradable, so their circular model is the mirror image of the natural fibres: keep the plastic circulating indefinitely in a closed technical loop, and never let it reach soil or sea. The model is: make fibre from recycled feedstock (rPET, regenerated nylon) rather than virgin oil; design mono-material products that avoid mixing polymers or adding elastane; build take-back and collection so garments return as feedstock; and recycle fibre-to-fibre — mechanically where possible and, increasingly, chemically, by depolymerising polyester or nylon back to near-virgin building blocks that can be recycled again and again. Two problems must be managed throughout: microplastic shedding (reduced by tighter weaves, wash-bag filters and gentler laundering) and the fact that elastane and multi-polymer blends still defeat most recyclers — so designing them out is the single highest-value move.

Blends and next-generation bio-materials

Blends are the hardest case: a poly-cotton or cotton-elastane fabric is neither cleanly compostable nor cleanly recyclable, so the circular priority is to design them out where possible, choose recyclable mono-materials, or rely on emerging chemical processes that can separate and recover cotton and polyester from a blend and are only now reaching commercial scale. Next-generation bio-materials — pineapple, cactus, grape, apple, mushroom, citrus and brewed-protein fabrics — are, by contrast, often circular by design: most begin as agricultural or food waste, and many are partly or wholly biodegradable. The caution is that some "leather alternatives" are finished with plastic (polyurethane) coatings or bound with fossil resins, which limits their compostability; the circular ideal for this group is a fully bio-based, coating-free material that can be composted or safely recycled at end of life.

Quick-reference: a circular model for each fabric

The table below summarises, for the fibres surveyed in Section Two, whether each is renewable and biodegradable, its main recycling route, and the single circular strategy that matters most.

Fabric	Renewable / biodegradable	Main recycling route	Priority circular strategy
Cotton	Yes / yes (if pure)	Mechanical; chemical emerging	Reuse & resale; keep unblended; regenerative farming
Linen · Hemp	Yes / yes	Mechanical; compost	Durability & reuse; compost pure items
Jute · Coir · Sisal	Yes / yes	Reuse; compost	Long-life uses; biodegrade at end
Banana · Pineapple	Yes / yes	Reuse; compost	Valorise agri-waste; avoid plastic coatings
Bamboo (viscose)	Yes / yes if pure	Cellulosic / chemical	Clean closed-loop processing
Wool · Cashmere	Yes / yes	Re-spin (recycled wool)	Reuse, repair, resale; re-spin
Silk	Yes / yes	Reuse	Longevity & resale; biodegrade
Alpaca · Mohair · Yak	Yes / yes	Reuse; re-spin	Durability & resale
Viscose · Rayon	Yes / yes if pure	Cellulosic / chemical	Certified or waste feedstock; clean process
Modal · Lyocell	Yes / yes	Chemical; compost	Closed-loop process; keep unblended

Fabric	Renewable / biodegradable	Main recycling route	Priority circular strategy
Cupro · Acetate	Yes / partly	Limited	Waste feedstock; keep unblended
Polyester	No / no	Mechanical & chemical	Recycled feedstock; mono-material; take-back
Recycled polyester	From waste / no	Fibre-to-fibre	Keep in a closed technical loop
Nylon	No / no	Chemical (regeneration)	Recycled nylon; mono-material design
Acrylic	No / no	Very limited	Avoid where possible; capture microfibres
Elastane	No / no	Not recyclable in blends	Design out; minimise use
Polypropylene	No / no	Mechanical	Mono-material; recycle in technical loop
Poly-cotton & blends	Mixed	Hard; chemical separation emerging	Design out; move to mono-materials
Piñatex · Cactus · Apple · Grape	Partly bio-based	Limited if coated	Remove plastic coatings; compost or recycle
Mushroom (mycelium)	Yes / yes	Compost	Keep coating-free; biodegrade
Orange · Milk · Soy · Brewed protein	Bio-based / mostly	Cellulosic/protein; compost	Waste feedstock; keep unblended
Recycled cotton	Yes / yes	Mechanical (blended)	Feed textile-to-textile recycling

Table S3.1 — A circular-economy snapshot for the world's main fabrics.

Read together, the pattern is simple. For fibres that come from nature, circularity means keeping them pure, wearing them long, and letting them return to the earth. For fibres that come from oil, it means never letting them leave the loop. And for the blends and new bio-materials in between, it means designing with the end in mind from the very first sketch — the theme of this whole book.

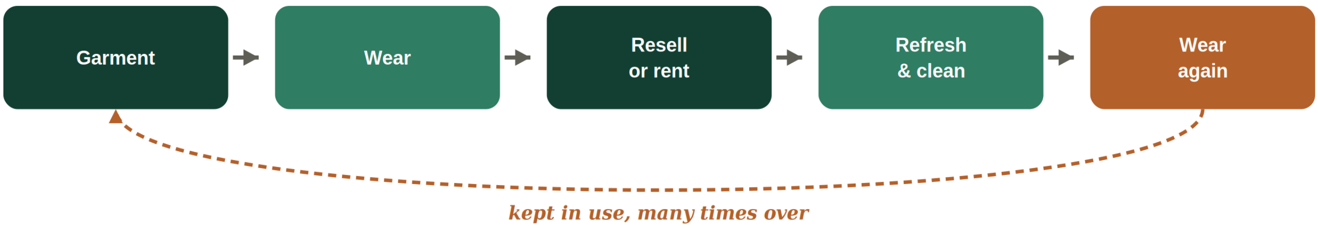
SECTION FOUR

Circular Models in Action

Section Three set out, in a table, the best circular strategy for each fabric. This section brings those strategies to life. It draws each model as a simple loop, then asks the two questions every organisation cares about — what are the benefits, and where is the market?

Eight models cover almost every fabric in this book. Some keep whole garments in use (reuse, rental, repair); some improve the inputs (regenerative sourcing); some recover the material (mechanical and chemical recycling, closed-loop manufacturing); and some turn waste into new material or return it to the soil (valorisation and composting). Market figures below are drawn from recent industry reports; sources are listed at the end of Section Five.

Model 1 — Reuse, Resale & Rental



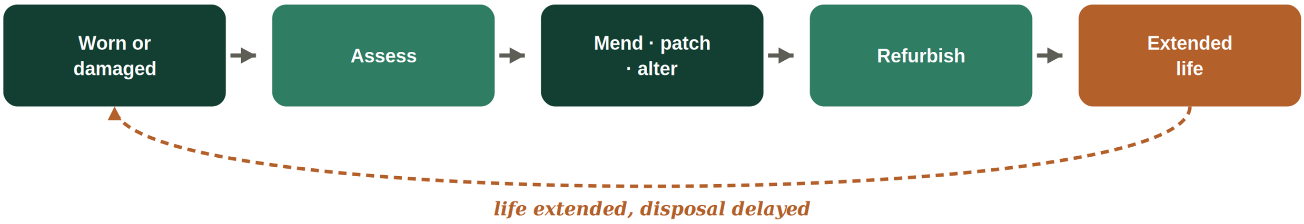
Applies to. Cotton, wool, cashmere, silk, linen, hemp, alpaca, mohair, yak — and any garment still wearable. This is the highest-value loop for almost every natural fibre.

Benefits. Keeping a whole garment in use spreads all the water, energy and carbon already embedded in it over many more wears, needs no reprocessing, and delays or avoids disposal altogether. It also makes fashion more affordable and accessible and earns income for sellers, platforms and brands. In the circular hierarchy, reuse sits near the very top — second only to simply using less.

The market & cost-benefit. The global second-hand apparel market reached about US$197 billion in 2023 and is forecast to hit roughly US$367–393 billion by 2029–2030, growing far faster than conventional retail (ThredUp / GlobalData Resale Reports). Rental and subscription add a smaller but fast-growing layer, worth on the order of US$1.6–2.1 billion in 2025 and projected to more than double within a decade (Fortune

Business Insights; Future Market Insights). The economics are compelling: reselling or renting a garment needs only cleaning and logistics — a fraction of the cost and impact of making a new one — while every additional cycle lowers the effective cost-per-wear and captures value that would otherwise be thrown away.

Model 2 — Repair & Refurbishment

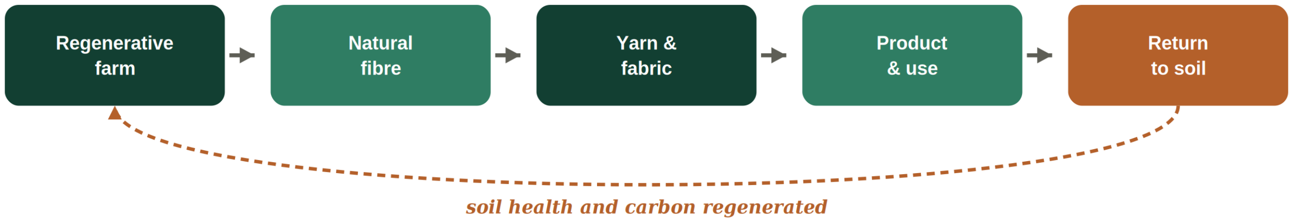


Applies to. Wool and cashmere knitwear, denim and cotton, tailored and durable garments, footwear and leather goods — anything worth mending.

Benefits. Repair extends a garment's active life at the lowest possible resource cost: it uses almost no new material and a tiny fraction of the energy of a replacement. It preserves value, deepens the bond between owner and garment, builds brand loyalty, and supports skilled local livelihoods — menders, tailors and cobblers.

The market & cost-benefit. Repair is harder to size than resale, but it is expanding on the back of right-to-repair momentum, brand repair and buy-back schemes, and EU rules that increasingly demand durability and repairability. The economics are strongly favourable: extending the active life of clothing by just nine months cuts its carbon, water and waste footprints by around 20–30% each (WRAP), while a repair typically costs a small fraction of a new item. That makes repair one of the highest-return circular interventions there is — for the wearer, and, through refurbished-stock resale, for the brand (Ellen MacArthur Foundation; WRAP).

Model 3 — Regenerative & Preferred Sourcing



Applies to. Cotton (organic and regenerative), linen, hemp and the natural animal fibres — the input side of every natural-fibre loop.

Benefits. This model tackles impact at the source rather than the end. Regenerative and organic farming rebuild soil, cut synthetic pesticide and fertiliser use, improve water retention and can store carbon in the ground; certified and preferred fibres add traceability and cleaner processing. Better inputs make every later loop — reuse, recycling, composting — cleaner and easier.

The market & cost-benefit. The market for sustainable fabrics — led by organic cotton — was worth roughly US$32 billion in 2024 and is projected to reach about US$74 billion by 2031 (~12.7% CAGR), with organic cotton the fastest-growing segment (Valuates Reports; Textile Exchange). Preferred and organic fibres carry a price premium and can involve yield variability and certification costs, but they meet fast-rising consumer demand, reduce regulatory and reputational risk, and — through healthier soils — can improve farm resilience and long-run yields.

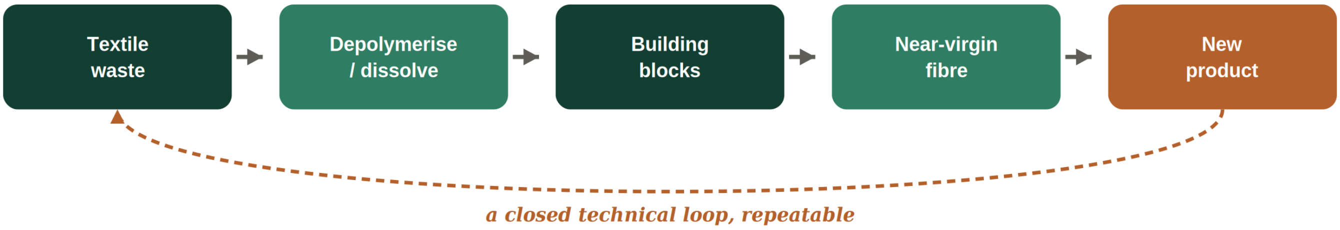
Model 4 — Mechanical Recycling

Applies to. Cotton and recycled cotton, wool (“shoddy” / recycled wool, as at Prato in Italy), and other clean, single-fibre textiles.

Benefits. Mechanical recycling is mature, low-energy and low-cost: it recovers fibre without chemicals and directly displaces virgin material. It is ideal for clean preconsumer offcuts and mono-fibre garments, and has been practised for generations — Panipat in India for cotton, Prato in Italy for wool.

The market & cost-benefit. Mechanical recycling is the largest slice of a textile-recycling market worth around US$8.4 billion in 2025 and forecast to reach roughly US$11.9 billion by 2030 (~7% CAGR), making up the majority — about three-quarters — of recycling activity today (MarketsandMarkets; Roots Analysis). Its cost advantage is real, but shredding shortens and weakens fibres, so output is usually blended with virgin fibre or downcycled. The best economics come from clean, sorted, single-fibre feedstock — which is why collection and sorting are the true value drivers.

Model 5 — Chemical / Fibre-to-Fibre Recycling

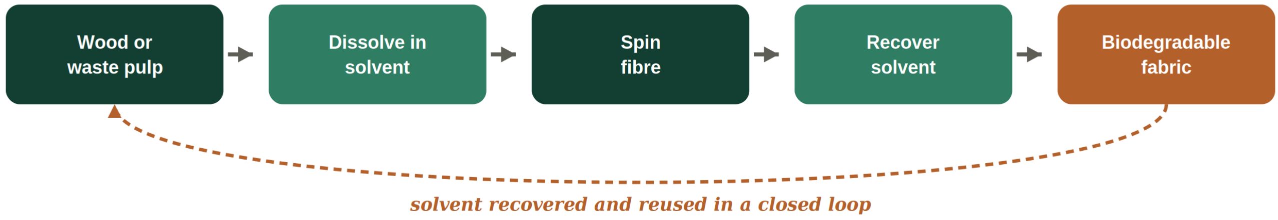


Applies to. Polyester and nylon (via depolymerisation), viscose, lyocell and cotton (via cellulosic dissolution) — and, critically, the blended fabrics that mechanical recycling cannot handle.

Benefits. Chemical recycling produces near-virgin-quality fibre that can be recycled repeatedly, keeping materials in a genuine closed loop. It can process dyed and blended textiles, and for synthetics it keeps plastic out of soil and sea. It is the technology that could finally lift textile-to-textile recycling above its current level of well under 1%.

The market & cost-benefit. This is the fastest-growing corner of the industry: the textile-to-textile recycling market was about US$2.8 billion in 2024, rose to roughly US$4.8 billion in 2025, and is projected to reach around US$44.8 billion by 2034 — nearly 25% a year — led by players such as Lenzing, Unifi (REPREVE), Circ, Infinited Fiber and SYRE (Global Market Insights). It is more energy- and capital-intensive than mechanical recycling and still scaling, but as plants come online and EU rules and digital product passports drive collection, unit costs are expected to fall — turning today's cost premium into tomorrow's advantage.

Model 6 — Closed-Loop Manufacturing



Applies to. The regenerated cellulosics — viscose, modal, lyocell and cupro.

Benefits. This model cuts pollution at the factory rather than the field or the bin. Closed-loop solvent systems, as used for lyocell, recover and reuse almost all of the chemicals and water, while waste-based or certified-wood feedstock lowers the footprint further. The output is a pure, biodegradable fibre that can later be composted or chemically recycled.

The market & cost-benefit. Clean, closed-loop cellulosics are a growing premium segment of the man-made-fibre market, championed by producers such as Lenzing, whose TENCEL lyocell process recovers more than 99% of its solvent. They cost more than conventional, polluting viscose, but they de-risk supply chains against tightening chemical and water regulation, meet rapidly rising demand for lower-impact fibres, and avoid the clean-up and reputational costs that dirty viscose increasingly attracts (Lenzing; Textile Exchange).

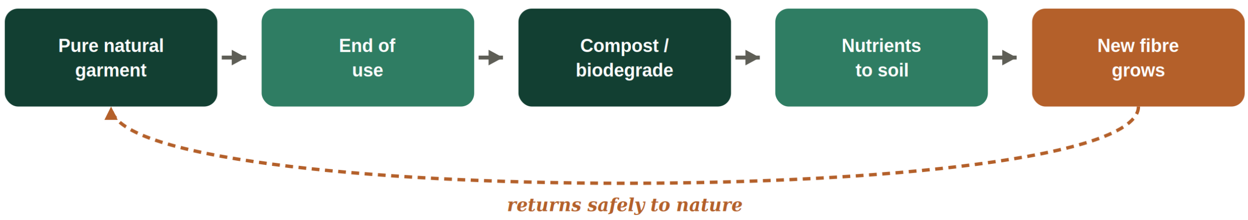
Model 7 — Waste-Feedstock Valorisation

Applies to. Banana, pineapple (Piñatex), cactus (Desserto), orange, grape, apple, milk, soy, mushroom and brewed-protein materials.

Benefits. This model is circular by origin: it turns agricultural and food-industry waste — leaves, peel, pomace, marc, surplus whey — that would otherwise be burned or dumped into valuable fibre and leather alternatives. It creates rural income while avoiding both waste and animal- or fossil-based materials.

The market & cost-benefit. These "next-generation" materials are a young but fast-growing market, projected to reach around US$2.2 billion by 2026 (about 3% of the wholesale-materials sector) and drawing well over US$1 billion in investment, with 140-plus innovator companies — most in leather alternatives — and strong brand pull; consumer surveys find around nine in ten shoppers open to buying them (Material Innovation Initiative; IDTechEx). Costs are still high and scale limited, and some materials rely on plastic coatings that must be engineered out; but because the feedstock is essentially free waste and demand is rising, the cost-benefit improves quickly with scale.

Model 8 — Composting & Biodegradation



Applies to. Pure, undyed or safely-dyed natural fibres — cotton, linen, hemp, wool, silk, jute — and fully bio-based materials such as mycelium leather.

Benefits. This is the gentlest end-of-life. Genuinely pure natural textiles can return to the soil as nutrients, closing the biological loop with no landfill, no incineration and no microplastics. It is the natural complement to regenerative sourcing — what the soil gave, the soil receives back.

The market & cost-benefit. Composting is not a large commercial market in its own right but a low-cost disposal route that avoids landfill and incineration fees and their emissions. Its value is unlocked by design and purity: only unblended, non-toxic textiles compost cleanly, so the cost-benefit depends entirely on keeping natural fibres free of synthetics and hazardous finishes upstream — which reinforces every other model in this section (Ellen MacArthur Foundation).

SECTION FIVE

When There Is No Circular Value

Not every fabric can be looped. Some are so cheap, so blended, so contaminated or so degraded that no circular-economy model is technically or economically feasible today. Pretending otherwise wastes effort. The honest response is to handle these materials responsibly — and to design them out.

Which fabrics fall outside the loop

- **Acrylic and other cheap synthetics.** They have almost no viable recycling route, pill and shed microplastics, and are rarely worth recovering.
- **Elastane / spandex.** It cannot be recycled and, worse, it contaminates whatever fibre it is blended into — a little elastane can make an otherwise recyclable garment unrecyclable.
- **Heavily blended fabrics.** Poly-cotton and multi-fibre technical textiles neither compost nor recycle cleanly, because their fibres cannot easily be separated.
- **Coated and bonded materials.** Some "leather alternatives" and finished fabrics are bound with polyurethane or fossil resins that block both composting and recycling.
- **Soiled, contaminated or degraded textiles.** Material carrying chemical, medical or hazardous residue — or so worn that no fibre can be recovered — has no circular value.
- **Mixed, unsorted waste.** Post-consumer waste with no viable separation is, in practice, residual.

How to handle them

Where circularity is not feasible, a clear hierarchy still applies — from best to last resort.

- **1. Design them out first.** The cheapest tonne of unrecyclable waste is the one never made. Specify mono-materials, avoid elastane where stretch is not essential, and choose recyclable or compostable fibres at the design stage.
- **2. Extend life as far as possible.** Even an unrecyclable garment should be worn, repaired and reused for as long as it lasts, to spread its impact and delay disposal.

- **3. Downcycle to the lowest useful grade.** Where fibre cannot be recovered for textiles, shredded material can still become insulation, mattress and furniture padding, wipers, geotextiles, acoustic panels or filler for composites and construction — real, if lower-value, uses.
- **4. Recover energy, carefully.** Genuinely unusable, high-calorific synthetics can be turned into refuse-derived fuel or sent to controlled energy-from-waste with emissions capture — better than landfill, though it destroys the material permanently and must be tightly managed.
- **5. Capture microfibres and manage safely.** For synthetics kept in use, filters, wash-bags and gentler laundering reduce microplastic release; contaminated textiles must follow hazardous-waste rules.
- **6. Landfill only as the true last resort** — and even then, prefer separated, inert material over mixed waste.
- **7. Back the R&D that will shrink this category.** Chemical and enzymatic processes that separate blends — cotton from polyester, elastane from the rest — are moving from lab to pilot to plant. Supporting them, and the collection and sorting they depend on, is how today's “no-value” fabrics become tomorrow's feedstock.

> **The point of Section Five**
>
> The goal is not to recycle the un-recyclable, but to **shrink this category towards zero by designing it out** — so that, in time, every fabric has a loop to belong to.

Sources for Sections Four & Five

Market figures and impact data above are drawn from the following recent public sources.

- ThreadUp / GlobalData — Resale Reports (2024–2026): global and US second-hand apparel market size and growth.
- Fortune Business Insights; Future Market Insights; Verified Market Research — online clothing-rental market size and forecasts.
- WRAP (UK) — Valuing Our Clothes: the environmental impact of extending garment life.
- Ellen MacArthur Foundation — A New Textiles Economy: circular principles and the value of reuse.
- Valuates Reports; Textile Exchange — sustainable-fabrics and organic-cotton market size; Materials Market Report.

- Markets and Markets; Roots Analysis; IMARC Group — textile-recycling market size and mechanical/chemical split.
- Global Market Insights — textile-to-textile (fibre-to-fibre) recycling market size and leading players.
- Material Innovation Initiative (State of the Industry); IDTechEx — next-generation and alternative-leather materials market and investment.
- Lenzing AG — closed-loop lyocell (TENCEL) solvent recovery.
- UN Environment Programme — global textile-waste volumes (~92–94 million tonnes a year).

Market sizes are indicative, vary between research houses, and are rounded; figures were current in early–mid 2026.

REFERENCES

Sources & Further Reading

The figures and developments in this book draw on recent public reporting from industry bodies, government agencies, academic reviews and specialist media. Key sources include the following.

- Textile Exchange — Materials Market Report 2025 (global fibre production and fibre mix).
- European Environment Agency & European Commission — textile consumption and waste data; revised EU Waste Framework Directive (2025) and EU Strategy for Sustainable and Circular Textiles.
- US Environmental Protection Agency — Facts and Figures on textiles in municipal solid waste; California SB 707, the Responsible Textile Recovery Act (2024).
- Seamless / Clothing Stewardship Australia and the Australia Institute — Australian clothing consumption, waste and the Seamless scheme.
- India Brand Equity Foundation (IBEF), Invest India & Ministry of Textiles — Indian textile sector size, employment, exports and clusters.
- Peer-reviewed reviews on textile dye wastewater, effluent pollutants and remediation (e.g. Holkar et al.; reviews in Springer, ScienceDirect and IWA journals).
- Reviews of mechanical, chemical and biological textile recycling technologies (2024–2025) and circular-textiles market analyses.
- The Ellen MacArthur Foundation — circular-economy principles and the framing of tighter and looser material loops.

Figures are indicative and rounded; where sources differ, this book cites the most widely reported recent estimates. Data current to early 2026.

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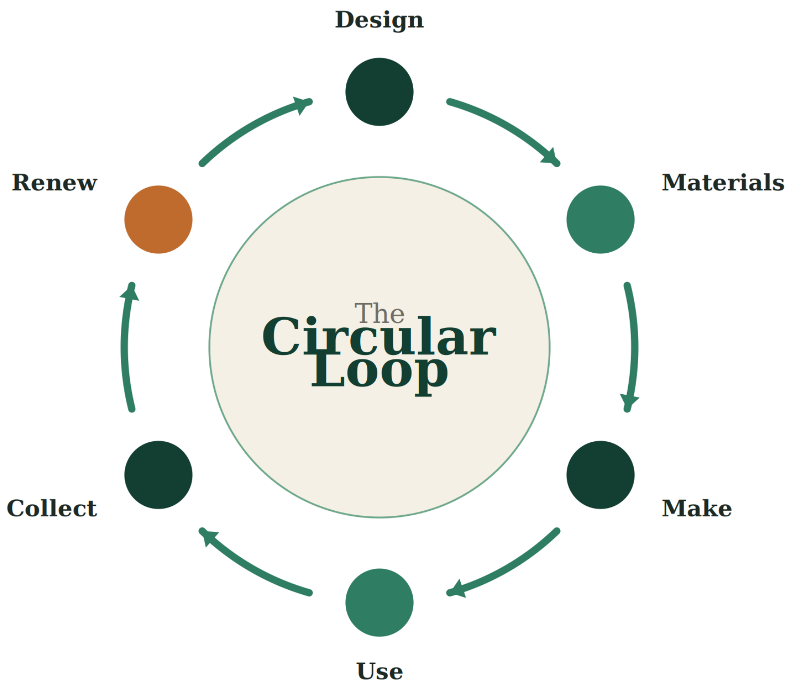

Closing the Loop

Textiles have clothed humanity for thousands of years by turning raw material into something useful and beautiful. The task of this generation is to ensure that when a textile's first life ends, its story does not — but loops back to the beginning.

Closing the loop is not a limit on the industry — it is its next chapter.

About the Institute

The Global Institute for Circular Economy and Sustainable Development Goals (ICE&SDGs) works at the meeting point of the circular economy, ESG and the UN Sustainable Development Goals.

Through research and policy insight, ESG and sustainability advisory, certifications, education, and applied programmes in GHG accounting, CSR and regeneration, it helps organisations turn ambition into measurable action.

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"The textile industry clothes the world and drives economies on every continent – it is also one of the most resource-hungry industries on Earth."

Closing the Loop explains, in plain language, how textiles are made, how much waste they create, and how the circular economy offers a practical way out. Written for sustainability and ESG professionals, brand and supply-chain teams, policymakers, students, and curious readers alike, it follows a garment's full journey — from fibre to landfill, and back again.