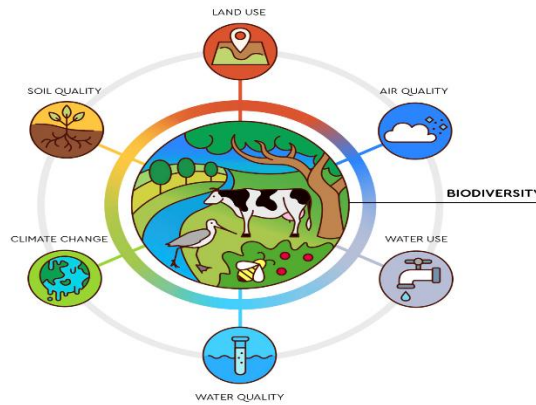


TEXTILE SUSTAINABILITY

UNIT-2

TEXTILE & CLOTHING SUSTAINABILITY

1. 360° Sustainability



A. Concept of 360° Sustainability

360° sustainability refers to a holistic approach that examines every stage of the textile and fashion lifecycle. It includes fibre production, dyeing, manufacturing, distribution, use, and end-of-life disposal. Instead of improving only one step, this model asks the industry to transform completely—from soil to store, and from customer use back to earth.

B. Full-Lifecycle Responsibility

This approach recognizes that every stage of fashion production has consequences: water pollution from dyeing, waste from cutting processes, microplastics from washing, and landfill accumulation from discarded garments. 360° sustainability pushes brands to design garments that last longer, use fewer chemicals, and cause minimal environmental harm throughout their journey.

C. Integration Across Stakeholders

A 360° model involves farmers, fabric mills, designers, factories, retailers, customers, and recyclers. Each participant becomes part of a circular chain, working together to reduce harm, increase efficiency, and create garments that are safe for both people and the planet. It encourages innovation, transparency, and shared responsibility.



1. 360° SUSTAINABILITY

A. Introduction to 360° Sustainability

- Definition and holistic approach
- Need for full-lifecycle evaluation
- Importance in the textile & fashion sector

B. Fibre-Level Sustainability

- Natural fibres vs. synthetic fibres
- Organic farming practices
- Water, pesticide, and energy considerations

C. Sustainable Fabric Production

- Eco-friendly dyeing and finishing
- Low-impact chemical usage
- Waterless dyeing technologies

D. Sustainable Garment Manufacturing

- Ethical labour practices
- Energy-efficient machinery
- Waste-minimizing cutting methods

E. Distribution & Transportation Impacts

- Carbon footprint of shipping
- Local vs. global supply chains
- Low-emission logistics strategies

F. Consumer Use Phase Sustainability

- Washing frequency and microplastic release
- Garment care methods to reduce impact
- Extending product lifespan

G. End-of-Life Sustainability

- Waste management systems
- Repair, reuse, recycling pathways
- Designing for circularity

H. Stakeholder Collaboration

- Role of brands, suppliers, consumers
- Multi-stakeholder partnerships
- Importance of shared responsibility

2. Sector Systemic Initiatives

A. Industry-Level Sustainability Programs

Sector systemic initiatives are collaborative efforts created by governments, brands, NGOs, and textile organizations to address sustainability challenges collectively. These initiatives focus on improving

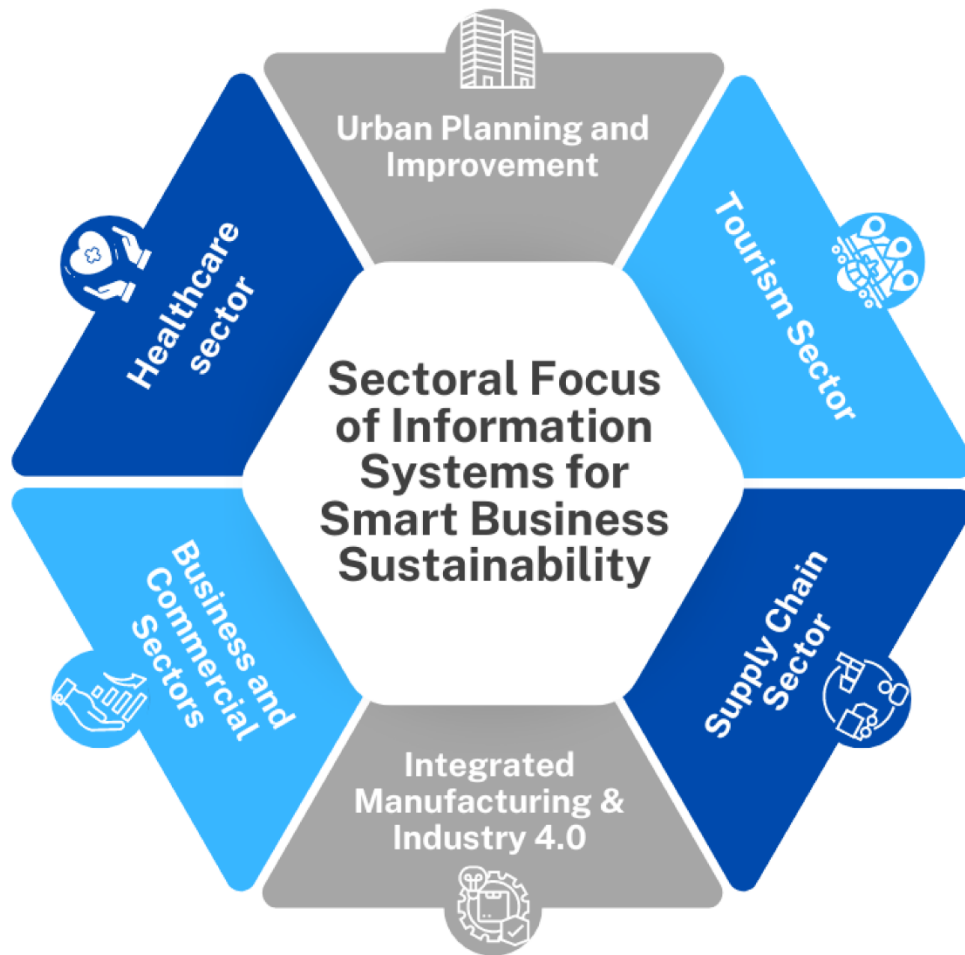
working conditions, reducing carbon footprints, and setting universal standards for sustainable production.

B. Collective Transformation

No single company can solve the environmental burden of the fashion industry. Therefore, systemic initiatives focus on group action—shared certifications, joint research, common waste-management systems, and harmonized sustainability goals. They encourage all players, big or small, to follow ethical and eco-friendly practices.

C. Examples and Impacts

Examples include the Sustainable Apparel Coalition (SAC), Ellen MacArthur Foundation Circular Economy Projects, and Better Cotton Initiative (BCI). Their impact is seen in improved traceability, reduced water usage, less chemical pollution, and stronger social compliance in factories. These systems create long-term, industry-wide transformation.



A. Understanding Systemic Initiatives

- Definition and purpose
- Need for collective industry transformation

B. Governmental Regulations & Policies

- National sustainability guidelines
- Pollution control laws
- Labour protection frameworks

C. International Sustainability Frameworks

- United Nations Sustainable Development Goals (SDGs)
- Paris Climate Agreement commitments
- ISO sustainability standards

SUSTAINABLE DEVELOPMENT GOALS



D. Industry Collaborations & Coalitions

- Sustainable Apparel Coalition (SAC)
- Ellen MacArthur Foundation initiatives
- Better Cotton Initiative (BCI)



E. Certifications and Standards

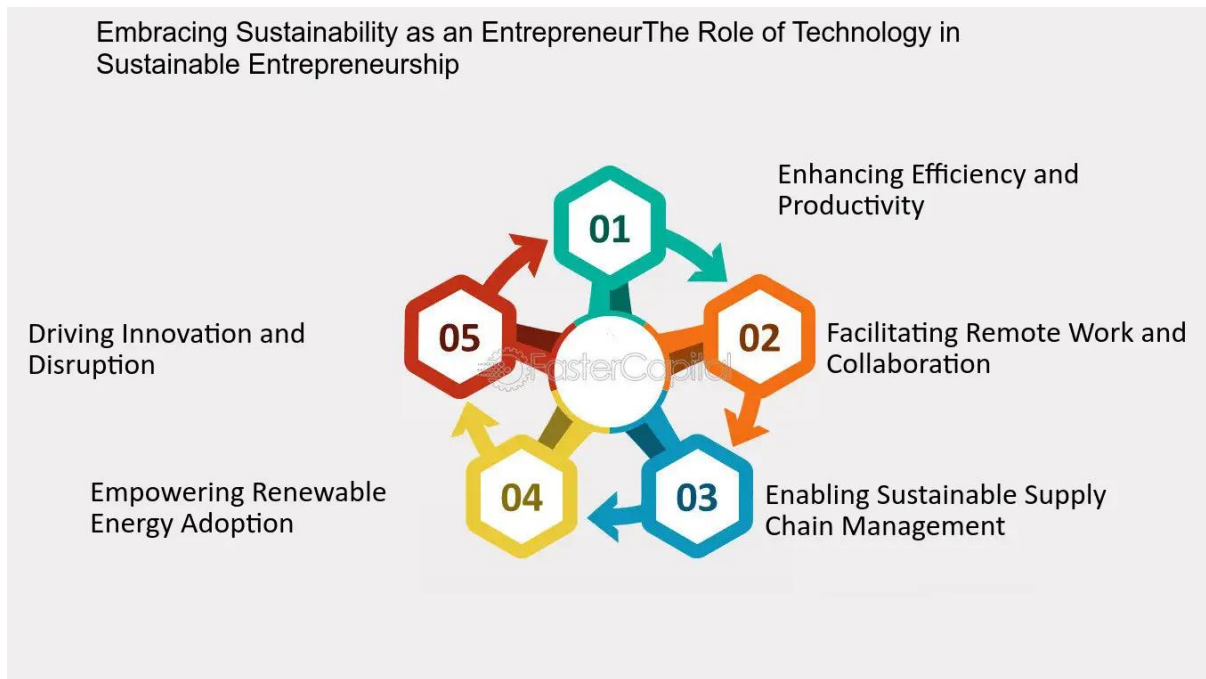
- GOTS, OEKO-TEX, Fair Trade
- Bluesign, Higg Index
- Importance of third-party verification

F. NGO & Civil Society Participation

- Role of environmental groups
- Worker rights organizations
- Community-led sustainability efforts

G. Technology-Driven Initiatives

- Blockchain for traceability
- AI for resource optimization
- Digital product passports



H. Impact Assessment & Reporting

- Measuring sustainability performance
- Transparent reporting practices
- Audits and compliance monitoring

3.Greenwashing

A. Understanding Greenwashing

Greenwashing occurs when brands pretend to be environmentally friendly without actually changing their harmful practices. It involves misleading claims, exaggerated “eco” labels, or vague marketing that confuses consumers. Greenwashing weakens trust and slows down real sustainability efforts.

B. Why Greenwashing Happens

Many fashion brands fear losing customers if they admit to unsustainable practices. Instead of making real changes, they use marketing phrases like “natural,” “organic-inspired,” “eco-friendly,” or “conscious” without proof. Because sustainability is trending, some companies exploit it for profit rather than genuine responsibility.

C. Identifying and Preventing Greenwashing

Real sustainability requires transparency—clear certification, scientific proof, and honest communication. Customers and companies must look for verifiable claims such as GOTS, Fair Trade, OEKO-TEX, and lifecycle impact statements. Preventing greenwashing strengthens trust, accelerates real progress, and encourages ethical competition within the fashion sector.



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Greenwashing:

a marketing tactic used by companies to **make their products or services appear more green and environmentally friendly than they actually are** to gain a competitive advantage over competitors.

It may seem effective, but it **undermines legitimate green initiatives** and it is **bad for the environment** as it distracts from actual sustainability efforts.

A. Introduction to Greenwashing

- Definition and meaning
- Emergence in the fashion industry

B. Types of Greenwashing

- Misleading labels
- Hidden trade-offs
- No proof claims
- Vagueness and ambiguity

C. Causes of Greenwashing

- Market pressure for sustainability
- Brand competition
- Lack of regulatory oversight

D. Common Greenwashing Tactics

- “Eco” phrases without evidence
- Use of Earth-tone packaging
- Overstating recycled content
- Highlighting one small green effort

E. Consequences of Greenwashing

- Loss of consumer trust
- Misleading sustainability progress
- Ethical concerns in brand communication

F. Identifying Greenwashing

- Checking for certifications
- Looking for data transparency
- Understanding lifecycle impact claims

G. Preventing Greenwashing

- Clear communication policies
- Third-party verification
- Authentic sustainability roadmaps

H. Role of Consumers & Media

- Educated consumer choices
- Media’s responsibility in exposure
- Social accountability movements

Types of Greenwashing



Greenhushing: Companies **underreport or hide sustainable credentials** to avoid scrutiny.



Greenrinsing: When a company **regularly changes its ESG** (Environmental, Social, Governance) targets **before achieving them**.



Greenlabeling: The **labeling** of an essentially **unsustainable product as green or sustainable**.



Greenlighting: The **highlighting of a particularly green feature** of a business's products or activities to draw attention away from its environmentally harmful actions.



Greenshifting: When companies reduce the climate crisis to consumer behavior and **shift responsibility to individuals**.



Greencrowding: When a company **hides within a group and is slow to adopt sustainability** policies (e.g. the 20 largest single-use plastic waste producers are members of the Alliance to End Plastic Waste global alliance).

4. Reuse, Recycling & Traceability

A. Reuse in the Fashion System

Reuse involves extending the life of garments through repairing, upcycling, sharing, swapping, or selling pre-loved clothing. This approach reduces waste, preserves resources, and encourages customers to value durability over disposability. Reuse celebrates creativity and redefines fashion as something timeless.

B. Recycling Processes

Recycling transforms textile waste into new fibres, fabrics, or products. Mechanical recycling breaks garments into fibres, while chemical recycling converts them into usable raw materials. Recycling reduces

landfill pressure, minimizes pollution, and closes the gap between production and waste—supporting circular fashion systems.

C. Traceability in the Fashion Supply Chain

Traceability allows brands and consumers to follow a garment's journey—from raw fibre to finished product. With technologies like QR codes, blockchain, and digital passports, traceability exposes hidden issues such as forced labour, pollution, or unsafe working conditions. It builds accountability and ensures sustainability claims are genuine.

4. REUSE, RECYCLING & TRACEABILITY

A. Reuse as a Sustainability Strategy

- Concept and importance
- Extending product lifespan

B. Forms of Clothing Reuse

- Upcycling and creative transformation
- Repair and restoration
- Second-hand selling
- Clothing rental systems

C. Community-Based Reuse Initiatives

- Swap events
- Donation drives
- Social enterprises

D. Textile Recycling Processes

- Mechanical recycling
- Chemical recycling
- Pre-consumer vs post-consumer waste

E. Challenges in Textile Recycling

- Mixed fibre content issues
- Quality degradation
- Sorting and collection difficulties

F. Circular Fashion and Recycling

- Closed-loop systems
- Designing recyclable garments
- Zero-waste fashion principles

G. Traceability in the Fashion Supply Chain

- Need for tracking materials
- Transparency in fibre-to-fashion journey

H. Tools and Technologies for Traceability

- Blockchain
- QR codes & RFID tags
- Digital product passports

I. Benefits of Traceability

- Ethical sourcing
- Quality assurance
- Consumer confidence

J. Traceability Challenges

- Data management
- Supplier cooperation
- Cost barriers

TUD Apparel



SUSTAINABLE TEXTILE MATERIALS

1. Fibre and Materials Market

A. Overview of Sustainable Fibre Markets

The global textile landscape is evolving, guided by a rising consciousness about environmental responsibility. Consumers today are no longer satisfied with clothing that merely looks good — they want garments that *do good*. This transition has created a dynamic marketplace where sustainable fibres are

gaining remarkable momentum. Governments, brands and NGOs collectively push the market forward by making sustainability a necessity rather than a choice. With climate change looming over the industry, fibres with low water consumption, responsible chemical usage, and reduced carbon footprints are increasingly preferred.

B. Natural Sustainable Fibres

Natural fibres harvested from plants and animals have re-emerged as champions of sustainability. Organic cotton, grown without synthetic pesticides or genetically modified seeds, helps restore soil health and protects farming communities. Hemp and linen, known for their strength and minimal water needs, are celebrated as ancient fibres making a modern comeback. Bamboo, when processed responsibly, offers softness combined with antimicrobial properties. Fibres like jute and sisal are strong, biodegradable and require little intervention to thrive, making them ideal for sustainable applications.

C. Regenerated & Bio-based Fibres

Regenerated cellulosic fibres bridge the worlds of nature and technology. Lyocell, marketed widely as TENCEL™, is produced using a closed-loop system where 99% of solvents are recovered and reused. Modal and viscose made from sustainably managed eucalyptus and beech forests are also becoming mainstream. In the realm of innovations, bio-based fibres derived from fruit waste — like orange peel, pineapple leaves (Piñatex) and banana stems — transform agricultural by-products into elegant textiles. These materials reduce pressure on landfills while empowering farmers with new income streams.

D. Recycled Fibres

Recycling is rewriting the future of textile materials. Recycled polyester (rPET), made from discarded plastic bottles, reduces dependence on virgin petroleum and lowers waste volumes. Recycled nylon — such as ECONYL® — is regenerated from fishing nets and industrial plastic waste, symbolizing the possibility of turning ocean pollution into luxurious fashion. Recycled cotton, wool and blended fibres are also gaining traction as mechanical and chemical recycling technologies advance.

E. Innovative Next-Generation Materials

Next-gen materials are disrupting traditional fibre production. Mycelium, the root structure of mushrooms, can be grown into flexible, leather-like textiles with minimal environmental impact. Lab-

grown cellulose fibres mimic natural fibres but require far fewer resources. Seaweed and algae-based fibres, with their natural cooling properties, represent the intersection of fashion and biotechnology. These innovations promise a future where textiles are grown — not manufactured.

F. Environmental Impacts of Different Fibres

Every fibre carries a story of its environmental footprint. Fibres such as conventional cotton demand vast quantities of water and pesticides, while synthetic materials contribute to microplastic pollution. Sustainable alternatives aim to reduce these impacts through better agriculture, more efficient production processes, and improved biodegradability. Understanding lifecycle impacts — from raw fibre to end-of-life disposal — allows brands to choose fibres that minimize harm to ecosystems.

G. Social Impacts in Fibre Production

Sustainability is never just environmental — it is deeply social. Fair wages, ethical treatment of workers and community well-being are intertwined with fibre production. Cotton farmers often face severe financial pressures and exposure to chemicals. Sustainable fibre markets aim to create safer working conditions, transparent wage systems and empowerment across the supply chain.

H. Market Drivers & Barriers

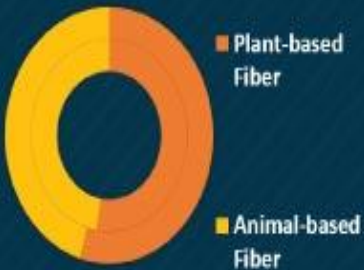
The rise of sustainability is powered by consumer demand, regulatory pressure and corporate responsibility. However, cost barriers, limited availability of sustainable fibres and lack of infrastructure slow progress. Education and deeper collaboration across supply chains are essential to overcoming these challenges.

Global Natural Fiber Market

Market Drivers

- Growth in demand for organic and eco-friendly products
- Rise in demand for lightweight materials in automotive sector

By Type



US\$ 4.8 Bn



In 2022 (A)

Market Revenue

CAGR (2023–2031)

7.5%

Key Players

- Barnhardt Natural Fibers
- Asha Cotton Industries
- The Flax Company SARL
- Dividan
- Castellins NV
- Jaydeep Cotton Fibers Pvt. Ltd

By End-use

- Packaging
- Agriculture
- Electrical & Electronics
- Textile
- Medical
- Others



By Region

- Asia Pacific
 - Largest market share in 2022



www.transparencymarketresearch.com



<https://www.transparencymarketresearch.com/natural-fiber-market.html>

2. PRODUCT CERTIFICATION AND VALIDATION

SUSTAINABLE FASHION CERTIFICATES

for material sourcing & environmental aspects



A. Importance of Certification in Sustainability

As sustainability becomes a buzzword, certifications act as a compass that distinguishes genuine commitment from superficial claims. Certifications validate environmental and social performance through strict testing, audits and standards. They build trust between producers, brands and consumers, ensuring that sustainability is not just a marketing promise but a measurable reality.

B. Fibre-Level Certifications

Certifications such as GOTS and OCS verify the authenticity of organic fibres and monitor farming practices. The Better Cotton Initiative (BCI) aims to uplift cotton farming techniques worldwide, focusing on water efficiency and soil conservation. Woolmark certifies wool quality and animal welfare standards, reassuring buyers that products meet high ecological criteria.

C. Chemical and Safety Certifications

Chemicals play a critical role in dyeing, finishing and processing textiles. OEKO-TEX Standard 100 and Bluesign ensure that harmful chemicals are eliminated from production, protecting both factory workers and end users. REACH compliance safeguards against toxic substances across European markets. These certifications are vital for limiting ecological and health impacts.

D. Environmental Impact Certifications

ISO 14001 and similar systems help companies systematically manage environmental responsibilities. Carbon footprint labels allow brands to quantify emissions associated with a product, while water stewardship standards promote responsible water management. These certifications hold companies accountable and encourage continuous improvement.

E. Social and Ethical Certifications

Fair Trade, SA8000 and ETI focus on human rights, labor conditions and equitable wages. They ensure that the hands behind a garment are protected, respected and compensated fairly. Ethical certifications reinforce the idea that sustainability is incomplete without social justice.

F. Lifecycle-Based Certifications

Cradle-to-Cradle evaluates products from resource extraction to disposal, encouraging circularity and safe material cycles. The Higg Index scores products on sustainability parameters, enabling brands to measure and compare performance. Life Cycle Assessments (LCAs) provide scientific analysis of environmental impacts across the product's lifespan.

G. Traceability and Reporting Tools

Modern supply chains are complex. Digital tools — including blockchain, QR codes and RFID tags — offer transparent tracking from fibre to finished product. Digital product passports store sustainability information that consumers can access easily. Such systems reduce fraud and increase trust.

H. Challenges in Certification

Certification is powerful but not perfect. The high cost of audits and complex documentation can burden small producers. Labels may be misunderstood or misused, leading to unintentional greenwashing. Simplification, education and accessible certification pathways are needed to make the system more inclusive.

3. REUSE OF WASTE MATERIALS



A. Importance of Waste Reduction in Textiles

The textile industry generates millions of tons of waste annually, much of which ends up in landfills or incinerators. Fast fashion accelerates this cycle by producing garments with short lifespans. Reducing waste is essential for protecting ecosystems, conserving resources and slowing climate change. Reuse strategies form the heart of a circular textile economy.

B. Pre-Consumer Waste Reuse

Before garments even reach stores, factories produce large amounts of cutting scraps, surplus yardage and rejected pieces. These materials can be transformed into accessories, patchwork textiles, insulation materials or recycled fibres. Brands adopting zero-waste cutting techniques and intelligent design can drastically reduce pre-consumer waste.

C. Post-Consumer Waste Reuse

Once garments are discarded by consumers, they enter the post-consumer waste stream. Collecting, sorting and repurposing these garments is a complex but essential step toward circularity. Thrift stores, donation centers, resale platforms and upcycling studios all contribute to giving garments a second life.

D. Reuse Methods

Upcycling breathes creativity into waste, converting old garments into unique, artistic pieces with higher value. Downcycling, although less glamorous, turns waste into functional products such as cleaning cloths or industrial materials. Repairing extends a garment's lifespan, while repurposing transforms materials into bags, cushions or home décor.

E. Recycling Pathways

Recycling technologies fall into two categories: mechanical and chemical. Mechanical recycling breaks textiles into fibres through shredding, while chemical recycling dissolves fibres back into their molecular form for regeneration. Fibre-to-fibre recycling promises a future where old garments continuously re-enter production cycles without degradation of quality.

F. Circular Fashion Systems

Circular fashion challenges the linear “take-make-waste” model by emphasizing longevity and reuse. Extended Producer Responsibility (EPR) policies hold brands accountable for waste management. Rental, resale and swapping platforms reduce the pressure of overproduction and give consumers more sustainable options.

G. Role of Technology in Waste Reuse

Advanced sorting machines can identify fibre types using near-infrared technology. Cutting-edge shredding machines preserve fibre length for higher-quality recycled fibres. Chemical depolymerization processes recover pure monomers from synthetics like polyester, enabling repeated recycling.

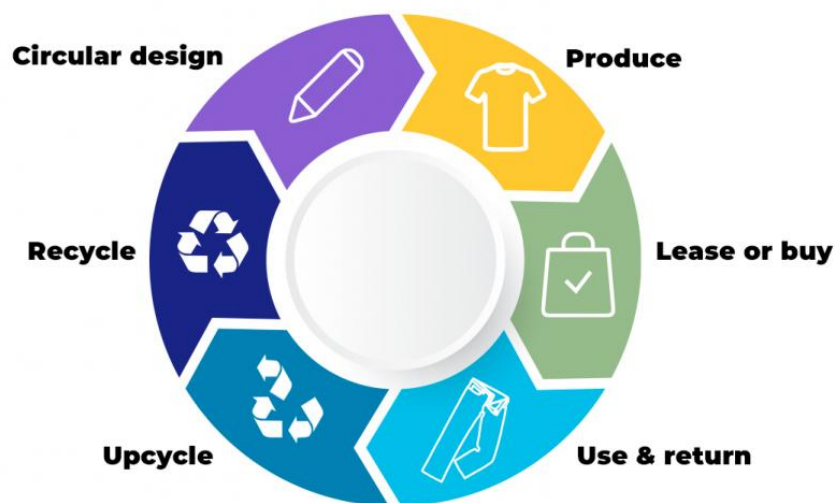
H. Social and Economic Benefits of Reuse

Waste reuse creates employment opportunities for artisans, designers, recyclers and repair specialists. It makes sustainable fashion more accessible and affordable. Communities benefit from reduced environmental pollution and increased awareness of conscious consumption.

I. Challenges in Waste Reuse

Garments made from blended fibres are difficult to recycle. Low-quality fast fashion items often lack the durability needed for reuse. Consumer behavior — driven by trends and convenience — remains one of the main obstacles. Education and incentives are essential to overcoming these barriers.

The future of fashion is the circular economy



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SUSTAINABLE TEXTILE MATERIALS

1. Fibre and Materials Market

A. Overview of Sustainable Fibre Markets

- Growth of eco-conscious consumer demand
- Shift from conventional to sustainable materials
- Global market trends and projections

B. Natural Sustainable Fibres

- Organic cotton
- Hemp
- Linen
- Bamboo
- Jute

C. Regenerated & Bio-based Fibres

- Lyocell (TENCEL™)

- Modal
- Viscose from sustainable forests
- PLA (polylactic acid) fibres
- Orange, pineapple (Piñatex), and banana fibres

D. Recycled Fibres

- Recycled polyester (rPET)
- Recycled nylon (ECONYL®)
- Reclaimed wool and cotton
- Textile-to-textile recycled fibres

E. Innovative Next-Generation Materials

- Lab-grown cellulose fibres
- Mycelium-based materials
- Bio-leather alternatives
- Seaweed and algae fibres

F. Environmental Impacts of Different Fibres

- Water consumption
- Chemical usage
- Energy requirements
- Biodegradability and end-of-life considerations

G. Social Impacts in Fibre Production

- Labour rights in cotton farming
- Fair wages in fibre production
- Ethical challenges in synthetic fibre manufacturing

H. Market Drivers & Barriers

- Consumer education
- Cost differences

- Supply chain limitations
 - Policy and regulation challenges
-

2. Product Certification and Validation

A. Importance of Certification in Sustainability

- Need for trust and transparency
- Reducing greenwashing
- Ensuring ethical supply chains

B. Fibre-Level Certifications

- Organic Content Standard (OCS)
- Global Organic Textile Standard (GOTS)
- Better Cotton Initiative (BCI)
- Woolmark certification

C. Chemical and Safety Certifications

- OEKO-TEX Standard 100
- Bluesign system
- REACH compliance

D. Environmental Impact Certifications

- ISO 14001 Environmental Management
- Carbon footprint certifications
- Water stewardship standards

E. Social and Ethical Certifications

- Fair Trade Certified
- SA8000 Social Accountability Standard
- Ethical Trading Initiative (ETI)

F. Lifecycle-Based Certifications

- Cradle-to-Cradle (C2C)
- Higg Index (product module)
- Life Cycle Assessment validation

G. Traceability and Reporting Tools

- Blockchain verification
- Digital product passports
- QR/RFID tagging systems

H. Challenges in Certification

- High cost of verification
 - Complexity of global supply chains
 - Misuse or misinterpretation of labels
-

3. Reuse of Waste Materials

A. Importance of Waste Reduction in Textiles

- Massive global textile waste statistics
- Environmental burden of landfills
- Fast fashion's contribution to waste

B. Pre-Consumer Waste Reuse

- Cutting waste in garment factories
- Yarn and fabric scraps
- Defective products and offcuts

C. Post-Consumer Waste Reuse

- Used garments
- Returned or damaged products
- Upcycling opportunities

D. Reuse Methods

- Upcycling (creative re-design)
- Downcycling (lower-grade products)
- Repair and refurbishment
- Repurposing (bags, accessories, home décor)

E. Recycling Pathways

- Mechanical recycling
- Chemical recycling
- Fibre-to-fibre recycling

F. Circular Fashion Systems

- Closing the textile loop
- Extended Producer Responsibility (EPR)
- Circular business models (rental, resale, swap)

G. Role of Technology in Waste Reuse

- Sorting innovations
- Shredding and re-fibreizing machinery
- Chemical depolymerization technologies

H. Social and Economic Benefits of Reuse

- Affordable clothing markets
- Employment through repair/upcycling
- Reduced burden on waste systems

I. Challenges in Waste Reuse

- Mixed fibre composition
- Low-quality fast fashion garments
- Consumer habits and lack of awareness