

SUSTAINABLE FASHION

Hostel ID - 78

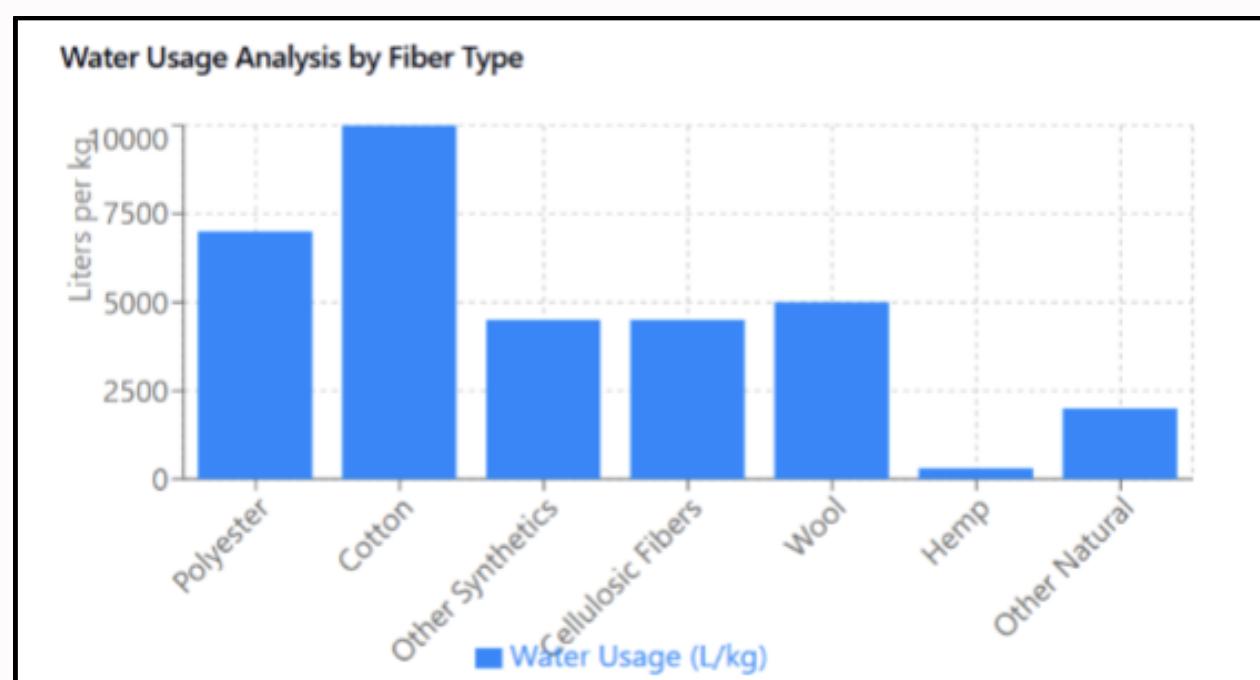
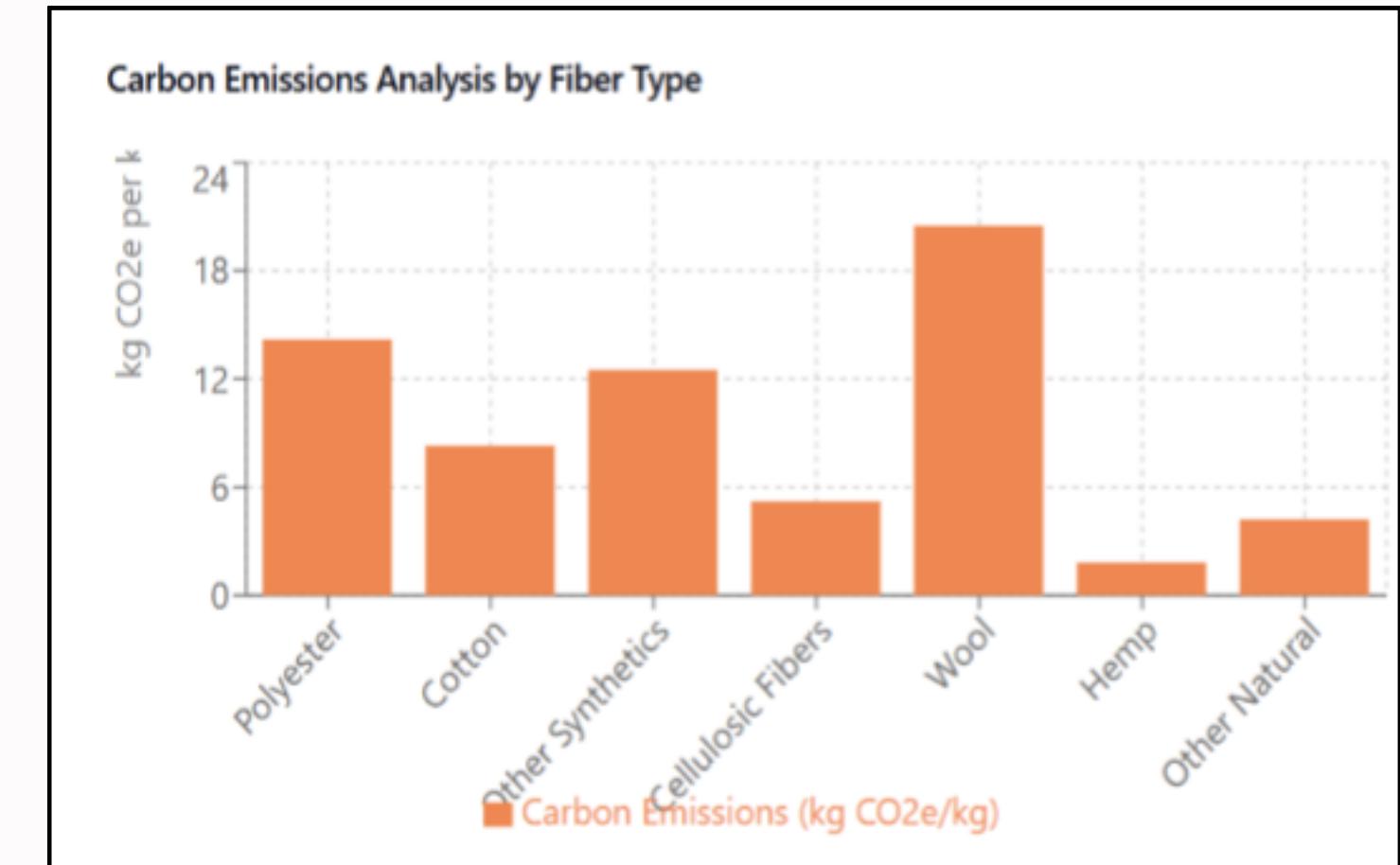


Overview

The fashion industry heavily relies on unsustainable practices, contributing **10% of global carbon emissions, excessive water usage, and massive waste generation**. Despite rising consumer demand for sustainability, progress toward eco-friendly and ethical practices remains slow and challenging.

Key Challenges in the Global Fashion Model

- Fast Fashion Dominance:** Fast fashion prioritizes speed and cost-efficiency, resulting in overproduction and waste. Consumers now buy **60%** more clothes than 20 years ago but keep them for **half the time**.
- Environmental Impact:** The fashion industry uses about **93 billion** cubic meters of water annually, enough to supply 5 million people. Textile dyeing contributes to 20% of global industrial water pollution. Around **92 million tonnes** of textile waste are generated each year, expected to rise to **134 million tonnes** by 2030.
- Carbon Emissions:** The industry emits approximately **1.2 billion** tonnes of CO₂ annually, more than international flights and maritime shipping combined.
- Supply Chain Issues:** Limited transparency in supply chains makes it difficult to track environmental and social impacts.
- Lack of Circular Economy Integration:** Only **1%** of clothing is recycled into new garments, with most ending up in landfills or being incinerated.



Market Overview

- Market Size:** The global fashion market was valued at approximately **\$1.7 trillion** in 2023, with projections to reach **\$2 trillion** by 2026, driven by fast fashion and e-commerce growth.
- Fast Fashion Segment:** The fast fashion market alone is valued at over **\$141 billion** (2024) and is expected to grow at a **CAGR of 10–15%** over the next decade.
- Sustainability Trends:** Sustainable fashion currently represents a small but growing segment, with increasing consumer demand for eco-friendly materials like organic cotton, recycled polyester, and biodegradable fabrics.

Introduction to Polyester

Polyester makes up **57%** of global fiber production, with **57 million tons** produced in 2023, expected to reach **63 million Tons** by 2025. While durable and affordable, it has major environmental impacts, including significant CO₂ emissions, microplastic pollution, and being non-biodegradable. The material is primarily derived from petroleum. Significant innovation and investment are needed to increase the use of sustainable alternatives.

- **57%** of global fiber production is polyester.
- **1.5 billion Tons** of CO₂ emissions are produced annually.
- Releases microplastics during washing.
- Takes hundreds of years to decompose in landfills.
- **99.97%** of polyester is derived from petroleum.
- Only **0.03%** comes from bio-based sources.

Environmental Impact of Switching to Bio-Based Polymers



Switching from petroleum-based polymers to bio-based alternatives involves initial higher costs but offers long-term environmental benefits, such as reduced carbon emissions, water usage, and waste generation.

Parameter	Petroleum-Based Polymers	Bio-Based Polymers
Cost per kg (in Rs)	80–160/kg	200–400/kg
Annual Usage (Example)	1,000,000 kg	1,000,000 kg
Annual Material Cost (in Rs)	8,000,000–16,000,000	20,000,000–40,000,000

Break-Even Point:

The break-even point could be reached within 3–5 years if oil prices rise or bio-polymer production scales up.

Year	Petro Cost (L)	Bio Cost (L)	Cum. Diff (L)	CO ₂ Saved (t)
2025	12.0	24.0	+12.0	1,500
2026	12.8	22.4	+7.2	3,000
2027	14.4	20.8	Break-Even	4,500



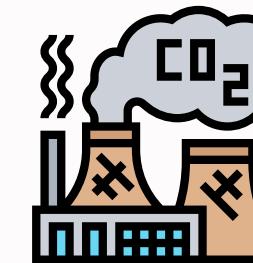
SOLUTION

A bio-based polymer is derived from renewable biological resources like plants, algae, or microorganisms, offering a sustainable alternative to petroleum-based plastics and fibers. These polymers, such as polylactic acid (PLA) made from corn, sugarcane, or cassava, and polyhydroxyalkanoates (PHA) made from vegetable oils and starches, have a reduced environmental impact. Additionally, cellulose and lignin from wood or agricultural residues can also be used in bio-based polymer production.



Cost Increase

Switching to bio-based polymers results in a **25–75%** cost increase depending on the polymer type and scale.



Carbon Footprint Reduction

- Petroleum-Based Polymers: 2.5–3.0 kg of CO₂ per kg.
- Bio-Based Polymers: 1.0–1.5 kg of CO₂ per kg.
- Annual Emission Reduction (for 1,000,000 kg annually):
 - Petroleum-Based Emissions: 2,500–3,000 tonnes of CO₂/year.
 - Bio-Based Emissions: 1,000–1,500 tonnes of CO₂/year.
- Carbon Reduction: 1,500 tonnes of CO₂/year (50–60% reduction).



Water Usage and Waste Management

- **Water Savings:** Producing 1 kg of PLA uses 10 liters of water, compared to 50 liters for petroleum-based plastics. Switching could save **40 million liters of water/year** for 1 million kg of production.
- **Waste Reduction:** Bio-based polymers are often biodegradable or recyclable, helping reduce landfill waste and supporting circular economy models.

Introduction to Cotton

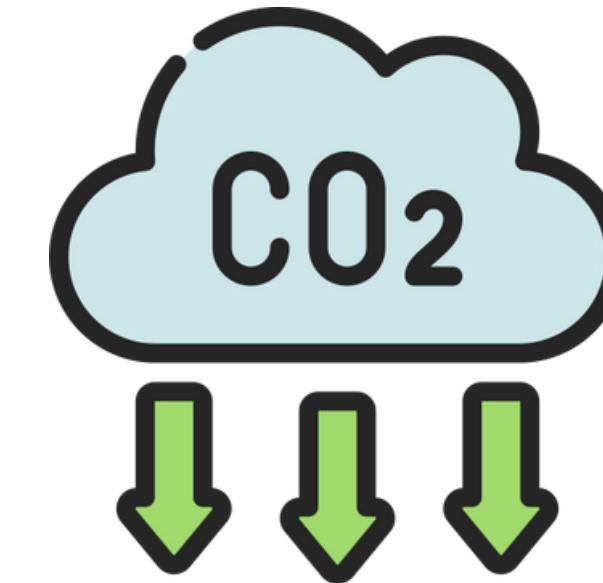
Environmental Impact Assessment

Soil Health and Conservation

The approach of no-till farming maintains soil structure integrity, significantly improving moisture retention capabilities and reducing irrigation requirements by up to 30%.

Water Resource Management

The relationship between cotton production and water consumption presents a critical sustainability challenge. Modern approaches such as drip irrigation have demonstrated significant potential, reducing water consumption by 20-50% through precise water delivery systems that target plant roots directly.



Carbon Emission Reduction Framework

Organic Farming Practices

The transition to organic cotton farming represents a fundamental shift in agricultural methodology. By eliminating synthetic fertilizers, farmers can achieve a 30% reduction in carbon emissions while simultaneously promoting soil health.

Technological Integration

The implementation of renewable energy systems, particularly solar-powered irrigation, has demonstrated the potential for a 30% reduction in operational emissions.

Integrated Pest Management Systems

The development of comprehensive IPM strategies combines various practices to minimize pesticide dependency. The implementation of these systems has demonstrated remarkable success, with pesticide cost reductions reaching 40% while maintaining effective pest control and promoting biodiversity within agricultural ecosystems.

Soil Carbon Sequestration Programs

Advanced soil management techniques, including cover cropping, biochar application, and reduced tillage practices, have shown significant potential for carbon sequestration. The economic benefits are substantial, with farmers potentially earning INR 5,000-10,000 per acre through government-sponsored carbon credit programs.



Cotton Continued...



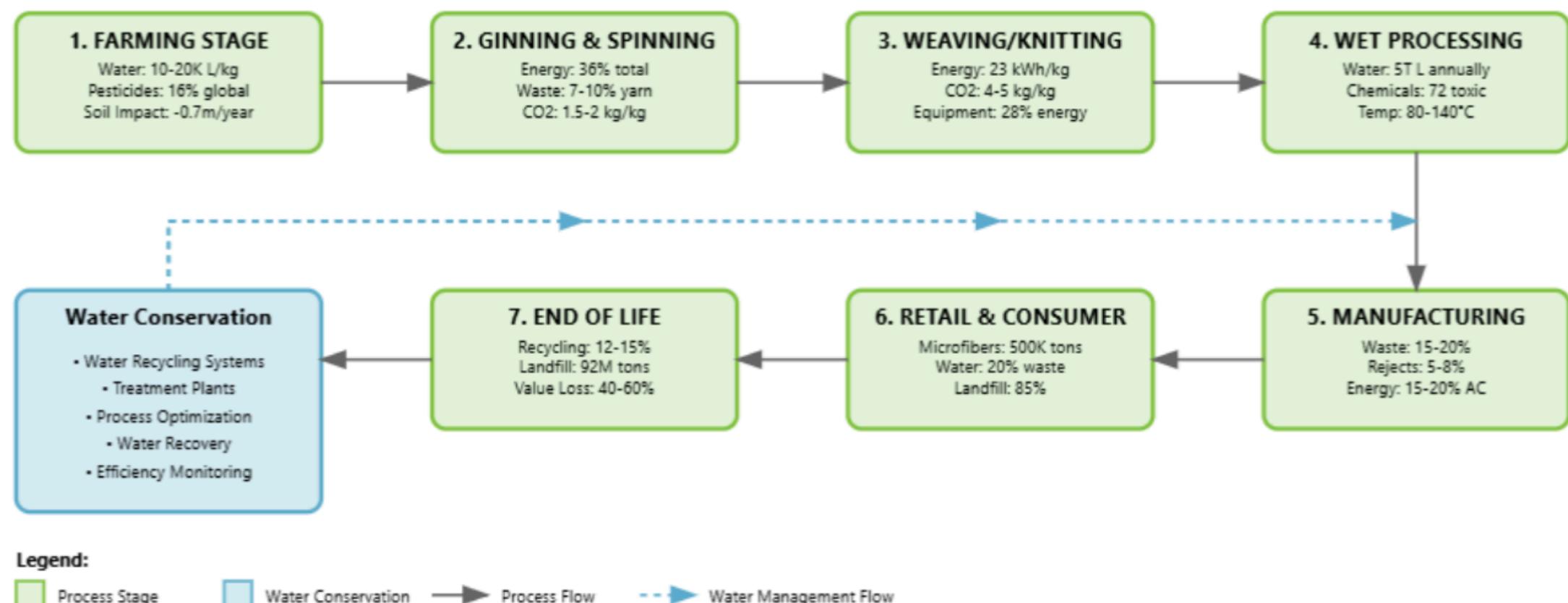
Comparative Analysis of Sustainable Solutions and Their Economic Benefits

Solution	Water Savings	Emission Reduction	Profit Margin (%)
Drip Irrigation	20-50%	15%	10-12%
Organic Cotton	30-40%	25%	15-20%
AI & IoT Smart Farming	10-20%	15%	15-20%
Chemical Recycling	60-70%	30%	20-25%
Hemp Production	50%	40%	25-30%
Integrated Pest Management	40%	10%	20-25%
Soil Carbon Sequestration	30%	40%	15-20%
Green Chemistry	30%	25%	15-20%

Hemp as a Sustainable Alternative

Hemp cultivation has emerged as a viable alternative to traditional cotton production, requiring **50%** less water and demonstrating superior carbon sequestration capabilities, absorbing **1.5-2** times more CO₂ per hectare than traditional forest cover. The market value for hemp fiber, ranging from **INR 2,000-2,500** per kilogram, reflects growing demand for sustainable textile alternatives.

Cotton Textile Supply Chain: Environmental Impact & Process Flow



Alternative Materials and Processing

Chemical Processing Innovations

The introduction of green chemistry principles in textile processing has revolutionized traditional manufacturing methods. The adoption of enzyme-based processes, bio polymers, and plant-derived dyes has significantly reduced the environmental impact of cotton processing. These innovations have achieved a **30%** reduction in water consumption and a **25%** decrease in carbon emissions, while maintaining product quality and improving workplace safety conditions.

Sustainable Alternatives to Cotton and Polyester: Rayon and Lyocell

Rayon (Viscose) Rayon is a semi-synthetic fiber made from wood pulp, accounting for **7%** of global fiber production. It is softer and more eco-friendly than polyester and cotton, with **1.8-3.2 kg** of CO₂ emissions and **4,000-8,000 liters** of water needed for 1 kg of fabric. However, Rayon's reliance on wood pulp leads to deforestation.



Sourcing Alternatives:

- **Bamboo**: Fast-growing, no pesticides needed.
- **Eucalyptus**: Sustainably managed and regenerated



Sustainability Solutions:

- **Certified Forest Sourcing**: Ensure wood pulp comes from sustainable forest
- **Bamboo & Eucalyptus**: Increase use of these sustainable alternatives.
- **Circular Fashion**: Recycle and upcycle Rayon fibers to reduce raw material demand.

Lyocell: A Greener Alternative

Lyocell is a semi-synthetic fiber made from wood pulp (typically from Eucalyptus or Bamboo) through a closed-loop process. It uses **5x** less water than cotton, recycles **99%** of water, and produces **50%** less CO₂ than Rayon.

Sustainability Advantages:

- Low water usage and non-toxic processing.
- Fully biodegradable and uses renewable wood sources.
- Lower carbon footprint than both Rayon and polyester.



Why We Suggest Using These Fabrics

We recommend increasing the use of Rayon and Lyocell in the fashion industry as they offer lower carbon emissions and reduced water usage compared to traditional fibers like polyester and cotton. Lyocell, especially, offers a closed-loop process that is biodegradable and eco-friendly. These materials can drive sustainability in fashion while offering profitable opportunities for brands looking to meet the growing demand for eco-conscious products.

Expansion Solutions

- Increased Investment in Lyocell production.
- Promote Adoption by brands looking for sustainable fibers.
- Consumer Awareness to drive demand for eco-friendly options.

FIBER	WATER USAGE	CO2	IMPACT
POLYESTER	High	5.5-9.0 kg	Fossil-fuel based, high energy use
COTTON	Very High	2.5-5.0 kg	Heavy pesticide & water use
RAYON	4,000- 8,000L	1.8-3.2 kg	Deforestation, lower emissions
LYOCELL	5x less than cotton	50% of Rayon	Biodegradable, low impact

Leather: Sustainability Challenges and Solutions

Leather is primarily used in the production of footwear, accessories, and outerwear, representing a smaller segment of the overall textile market. Analyzing the leather supply chain reveals that the tanning process is the most polluting. Tanning involves treating animal hides with chemicals to make them resistant to water, heat, and abrasion. However, this process requires large amounts of water and results in high carbon emissions due to heavy chemical usage.



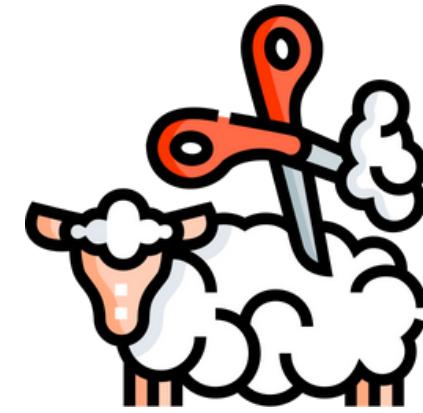
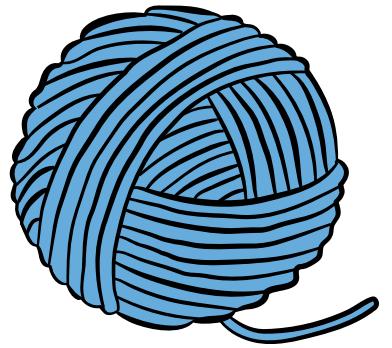
Making Tanning Sustainable

The tanning process often uses chemicals like chromium, which creates toxic sludge. To address the environmental impact, several alternatives can be implemented:

- **Zeolite-Based Tanning**: Use Zeology, a chrome-free, heavy metal-free, and aldehyde-free tanning agent. This method offers sustainability benefits while improving leather performance.
- **Plant-Based Tanning**: Adopt natural, plant-based tanning agents from sources like mimosa trees, tara trees, and valonia. These have minimal environmental impact.
- **Mixed Tanning Processes**: Combine vegetable and chrome tanning to achieve a balance between naturalness and color intensity while reducing environmental impact.
- **Water-Efficient Processes**: Implement technologies like Dri'Tan, which significantly reduces water usage and minimizes the need for chemicals in the tanning process.

Wool: A Premium Renewable Fiber

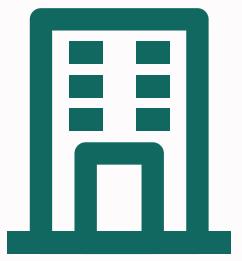
Wool is considered a premium product, with higher costs due to the labor-intensive farming, processing, and finishing stages, as well as the costs associated with transportation and waste management. Wool accounts for approximately **1-2%** of global fiber production.



Why to use Wool?

- **Renewable Raw Material**: Wool is naturally renewable, as sheep produce fleece annually, which can be harvested without harm to the animals.
- **Recycling Wool**: Wool is highly recyclable and can be reused multiple times without significant loss of quality.
- **Closed-Loop Recycling**: Wool garments can be shredded into fibers, re-spun into yarn, and used to create new textiles, reducing the need for virgin wool and minimizing textile waste.
- **Long Product Lifespan**: Wool garments are durable and long-lasting, reducing the frequency of replacement and minimizing waste generation.
 - Vintage wool garments are also highly sought after, promoting reuse in second-hand markets.

What is Fast Fashion?



Fast fashion refers to the rapid production of inexpensive, trend-driven clothing, making garments easily accessible but contributing to poor quality, waste, and significant environmental damage.

Environmental and Economic Problems :-

- Textile Waste
- Resource Consumption
- Exploitive Labor Practices



Solutions to Reduce Fast Fashion's Impact

Consumer Actions

- **Buy Smarter** : Choose durable, well-made clothing that lasts longer.
- **Support Sustainable Brands** : Opt for companies committed to eco-friendly materials
- **Recycling** : Participate in clothing recycling programs

Government & Policy Interventions

- **Extended Producer Responsibility (EPR)** : Hold brands accountable for disposal and recycling of their products.
- **Tax Incentives & Penalties** : Reward sustainable brands and penalize polluting companies.
- **Regulations on Overproduction** : Set limits on mass production to reduce waste.

Resale, Rental, and Repurposing

- **Second-Hand Fashion** : Platforms like ThredUp and Poshmark extend the lifespan of garments.
- **Clothing Renta** : Services like Rent the Runway reduce new production needs.
- **Upcycling** : Old clothes can be repurposed into new garments or household items.

For Brands

- **Sustainable Design** : Focus on high-quality, eco-friendly materials and ethical production.
- **Circular Business Models** : Implement take-back programs, rentals, and repair services to reduce overconsumption.

For Consumers

- **Buy Less, Wear More** : Invest in versatile, timeless pieces.
- **Care for Clothes** : Wash less, air dry, and repair garments.
- **Embrace Second-Hand Fashion** : Participate in thrift shopping and clothing swaps

Shifting to Slow Fashion and Circular Economy

Circular Economy

The fast fashion industry operates on a linear model—produce, use, and dispose—which leads to massive environmental damage and economic loss. Key issues include high resource consumption, waste generation, and premature garment disposal. To combat this, a circular economy focuses on reducing waste and maximizing material use through three strategies: Reduce, Reuse, and Recycle.

Solutions for a Circular Fast Fashion Supply Chain

Sustainable Material Sourcing

Organic cotton has emerged as a leading alternative, demonstrating remarkable efficiency by using **91% less water** than conventional cotton while **reducing CO2 emissions by 50%**. In parallel, recycled polyester, derived from PET bottles, has revolutionized synthetic fabric production, achieving a **75% reduction in emissions** while significantly decreasing dependency on petroleum resources.

Resale and Rental Economy

The fashion industry has witnessed a transformative shift toward circular consumption models through various innovative platforms and services. The emergence of subscription-based services, exemplified has fundamentally altered consumption patterns by reducing the need for new production. Furthermore, peer-to-peer platforms including ThredUp and Poshmark have achieved remarkable success in waste reduction, demonstrating their ability to **cut textile waste by almost 50%**.

Closed-Loop Recycling & Upcycling

The development of advanced recycling technologies has revolutionized end-of-life management for textiles. Mechanical recycling process, which involve shredding used garments into new fibers, have demonstrated remarkable effectiveness in waste reduction, **preventing 92 million tons of textile waste** annually from reaching landfills. Complementing this, chemical recycling technologies have advanced significantly, particularly in the regeneration of synthetic fabrics like polyester

Digital Transparency and Smart Supply Chains

The integration of advanced technologies has dramatically improved supply chain transparency and efficiency. Block chain technology has emerged as a powerful tool for tracking garment lifecycles, effectively combating green washing while ensuring accountability throughout the supply chain. The implementation of AI-driven demand prediction systems has revolutionized inventory management, leveraging data analytics to prevent overproduction and achieve a **30% reduction in inventory waste**.

Impact of Circular Fashion on Sustainability

Sustainable materials have demonstrated remarkable resource efficiency, achieving savings of **50k L liters of water per ton** of material while **reducing carbon emissions by 1.5 tons CO2 per ton** production. The resale and rental sector have contributed to environmental conservation, saving **40K L of water per ton** of water per ton and reducing carbon emissions by **1.2 tons CO2 per ton**. These initiatives have also shown substantial impact, conserving **30k L of water per ton** while achieving carbon reduction of **1.0 ton CO2 per ton**.

Circular Economy

The Transparency Crisis in Textile Manufacturing

Manufacturing Transparency

The current manufacturing landscape is characterized by limited disclosure practices, where brands typically only reveal their top-tier suppliers while obscuring the complex network of subcontractors. This selective transparency masks potentially poor labor conditions and environmental practices throughout the supply chain. To address these challenges, a comprehensive approach is necessary. The implementation of mandatory supplier disclosure requirements would create accountability throughout the entire supply chain. This must be coupled with stricter enforcement of labor and environmental regulations.

Retail Sector Challenges

Within the retail sector, the lack of transparency manifests primarily through insufficient supplier data sharing and inadequate consumer information regarding product ethics. A fundamental transformation of retail transparency requires the establishment of mandatory supply chain disclosure protocols. This should be supported by standardized sustainability labeling guidelines that enable consumers to make informed purchasing decisions. The integration of **QR-code tracking systems** for ethical sourcing verification represents a technological solution that could significantly enhance supply chain visibility and consumer awareness.

Overproduction Issues

The opacity surrounding production data has resulted in significant overproduction issues within the fashion industry. This lack of transparency directly contributes to **excessive inventory accumulation and unnecessary waste generation**. The solution lies in implementing data-driven production limits based on real-time sales analysis. Supporting this, the industry should transition toward made-to-order manufacturing models, facilitated by targeted financial incentives. **Mandatory disclosure requirements** for surplus disposal methods would create accountability for production decisions and waste management practices.

Disposal Management

Current disposal practices in the fashion industry remain largely unaccountable, with unsold inventory frequently being destroyed through burning or landfill disposal without public oversight. The implementation of **Extended Producer Responsibility (EPR)** frameworks represents a crucial step toward holding brands accountable for their waste generation. This should be complemented by strategic regulation of textile disposal through targeted bans or taxation mechanisms. Additionally, mandatory public disclosure of waste management practices would create transparency and encourage more sustainable disposal methods.

Recycling Infrastructure

The recycling segment of the fashion industry suffers from both a lack of **transparency and insufficient collaboration** among stakeholders. To address these shortcomings, the industry requires the establishment of mandatory recycling targets for brands, supported by robust monitoring and reporting systems. Significant investment in circular economy initiatives is essential to promote effective textile reuse and recycling programs. The development of stronger partnerships would enhance the efficiency.



Dyeing Optimisation for Sustainability

The textile dyeing process is a significant contributor to environmental pollution, particularly in terms of water usage and contamination. Traditional dyeing methods consume vast amounts of water and release hazardous chemicals into ecosystems. To mitigate these impacts, innovative solutions such as **Supercritical Carbon Dioxide (SC-CO) dyeing** and the reuse of residual dye baths have been proposed.

Environmental Impact of Traditional Dyeing

- Water Consumption: Conventional dyeing processes can use up to **200 liters of water per kilogram** of fabric.
- Pollution: Approximately **20%** of global industrial water pollution is attributed to textile dyeing and finishing treatments.

Cost Benefit analysis of proposed Solution

Solution	Initial Cost (cr)	Annual Savings (cr)	Water Savings (L/yr/ton)	Carbon Cut (t/yr/ton)	Break-Even
SC-CO Dyeing	16–40	8–10	200,000	1.5	3 years
Residual Dye Bath Reuse	0.8	3–6	100,000	0.8	1–2 years

Proposed Sustainable Alternatives

(SC-CO) Dyeing

Environmental Benefits:

- Water Usage: Completely eliminates water from the dyeing process.
- Energy Consumption: Reduces energy requirements by approximately **20%** compared to traditional methods.
- Waste Reduction: Generates no wastewater, as CO₂ is recycled within a closed system.

Cost Analysis:

- Initial Investment: Estimated between 16 crore to 40 crore for SC-CO dyeing equipment.
- Operational Costs: Lower than traditional methods due to savings in water and energy.

Reusing Residual Dye Baths

Environmental Benefits:

- Water Usage: Reduces water consumption by up to **50%**.
- Waste Reduction: Minimizes wastewater discharge and decreases the need for fresh dyes and chemicals.

Cost Analysis:

- **Initial Setup:** Approximately **80 lakh** for filtration and treatment systems.
- **Operational Costs:** Primarily maintenance of filtration systems, leading to overall cost savings.



Thankyou

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