Modular Course B: Creative Design in shoe Industry

Unit B3 – Design for Sustainability

Lecture LB3.1 – Biodegradable and Recyclable Materials in F&L Goods

Co-funded by the Erasmus+ Programme of the European Union

DISHOLEA | Improving the digital skills of workforce in Shoe and Leather goods Industry in Jordan and Palestine | GA 101129194

T2.2 – Development of modular courses and training material.

D2.2 – Modular Course in Creative Design

Contents

Introduction: Why Sustainable Materials Matter

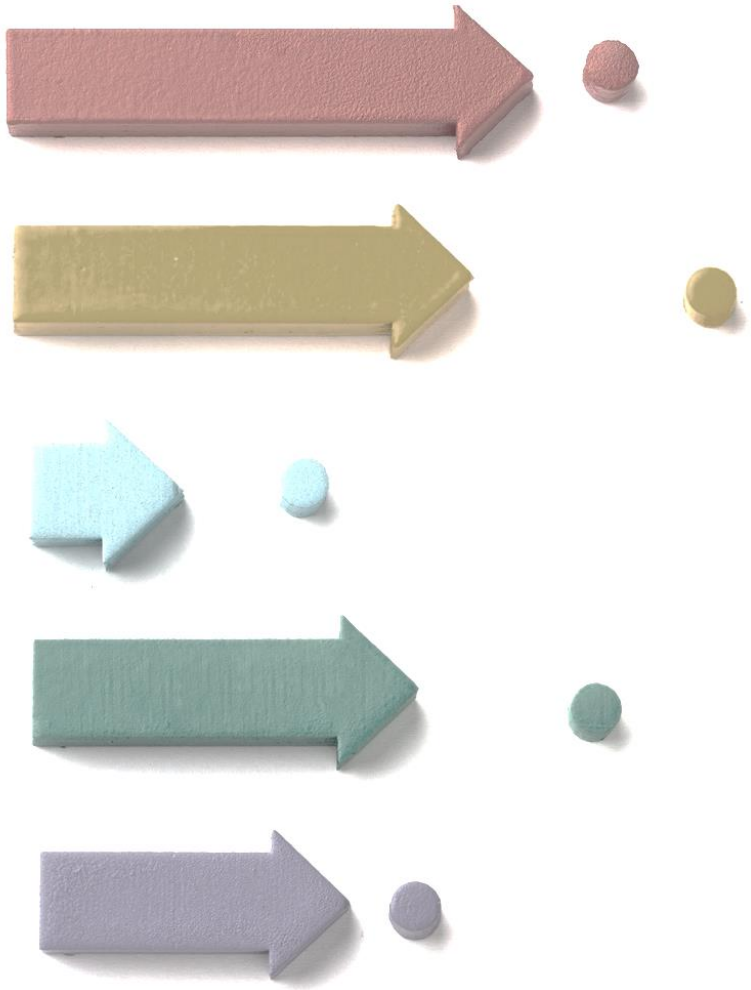
- **Environmental impact**
  reduce pollution, resource use, waste

- **Ethical considerations**
  fair labor, animal welfare

- **Consumer demand**
  eco-conscious customers seeking green products

- **Innovation**
  new materials driving creativity in design

Key Features of Sustainable Materials



- Classification of materials and components (recycled, recyclable, biodegradable)
- Origin and related transportation impact
- Eco-friendly production with minimal chemicals and energy
- Use of water-based solvents and adhesives
- Lightweight, durable, and high-quality
- Elimination of unnecessary materials and components
- Reduction of hazardous and restricted substances
- Use of renewable resources
- Simplified and efficient manufacturing

Natural Materials in Footwear

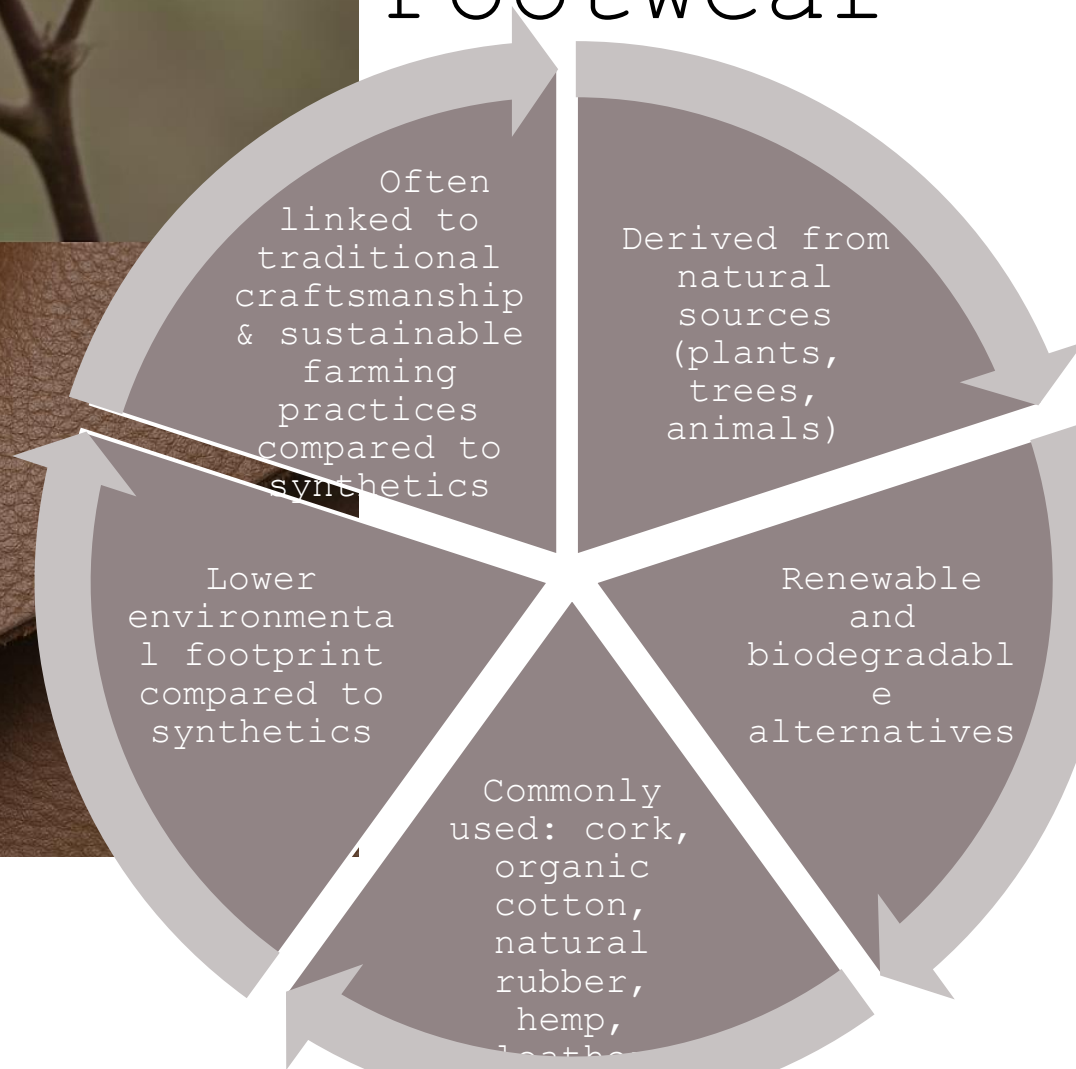
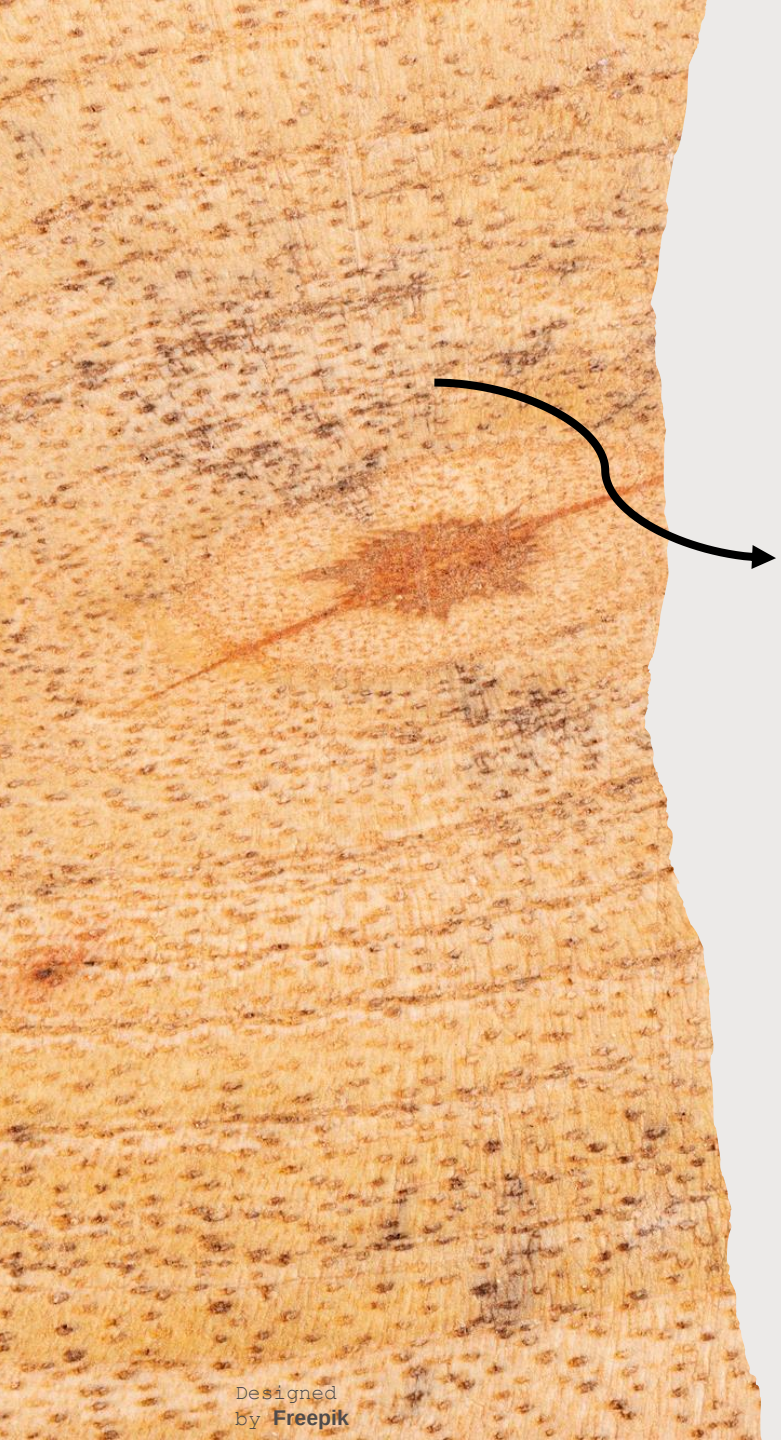


Image generated with DALL·E and adapted by Sofia Plakantonaki



Cork in Footwear

- Natural, renewable, and biodegradable material
- Harvested from the bark of cork oak trees (trees regenerate bark)
- Lightweight and durable
- Commonly used in wedges, platforms, decorative details and insoles
- Provides insulation and comfort properties

Designed by Freepik

Organic cotton

Organic cotton is cultivated without synthetic pesticides or GMOs, promoting healthier ecosystems and soil biodiversity. It reduces water and chemical use compared to conventional cotton and supports sustainable farming practices.

Market Insights (2023/24)

- 🌱 **Global organic cotton (2023/24):** ~706,000 tonnes
- 📊 **Share of world cotton:** 2.9 % (up from 2.3 % in 2022/23)
- 📈 **Growth:** +132,000 tonnes vs. previous year
- 🌍 **Global cotton total:** ~24.1 million tonnes
- ✓ **Certified under programs:** ~8.3 million tonnes (34 % of world cotton)
- 🏭 **Main producers:** India, Turkey, China, Kyrgyzstan, Tanzania

Natural Rubber

Properties & Performance

- Highly flexible and elastic → supports movement and comfort
- Strong abrasion and wear resistance
- Provides good insulation and grip

Challenges

- Plantation expansion may lead to deforestation and biodiversity loss
- Vulnerable to climate change (temperature, rainfall, pests)
- Market price

Sustainability Aspects

- Renewable & biodegradable material (Latex of Hevea brasiliensis)
- Lower carbon footprint compared to synthetic
- Supports rural livelihoods in producing countries (Asia, Africa, Latin America)

Applications in Footwear

- Outsoles for sports and casual shoes
- Insoles and cushioning layers
- Eco-friendly sneaker collections (brands increasingly blending natural rubber with

Hemp

Fast-growing

- Matures in 3-4 months
- Requires little land compared to cotton

Low resource demand

- Matures in 3-4 months
- Requires little land - compared to cotton

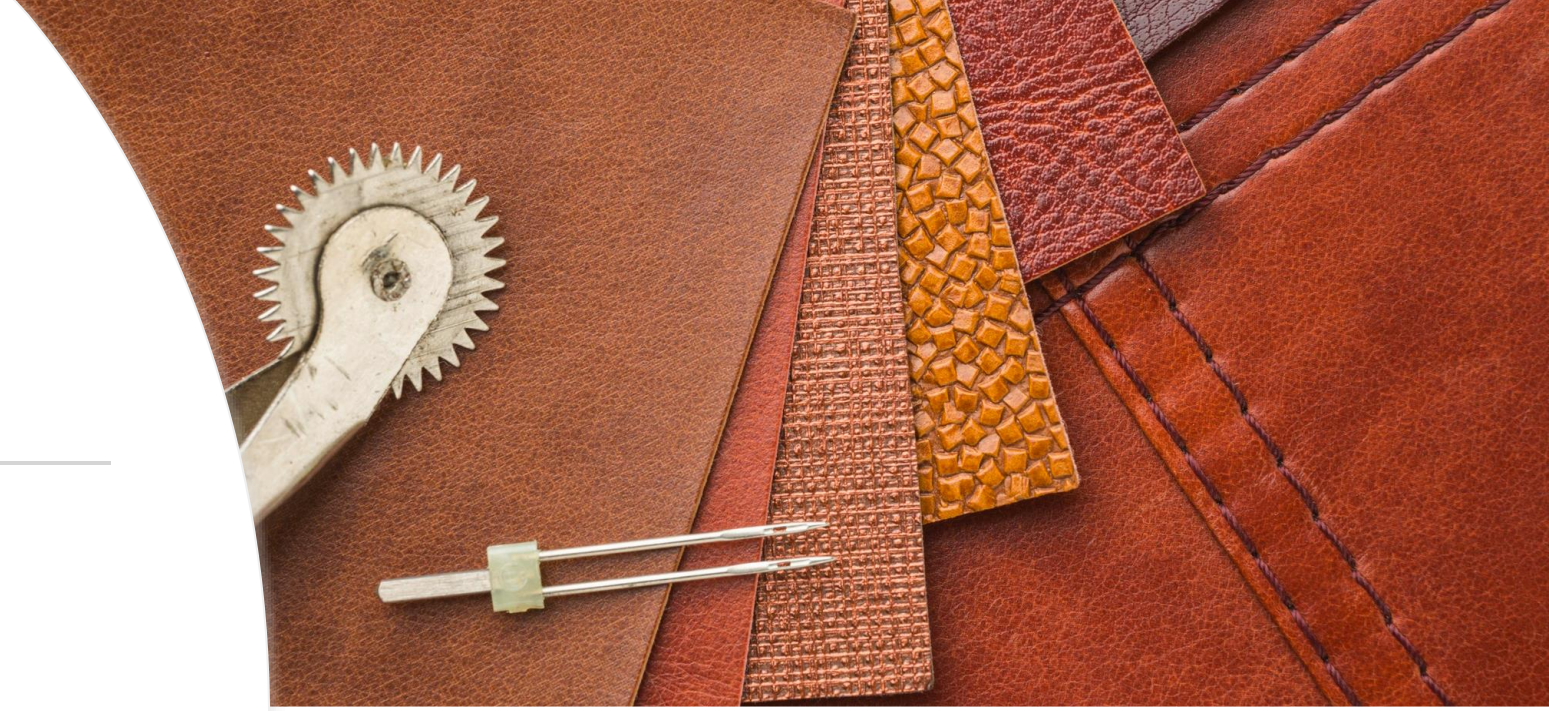
Durable fibres

- Strong and long-lasting
- High breathability and moisture absorption

Versatile uses

- Uppers, laces, linings, insoles
- Blended with other fibres for textiles

Leather



Eco-potential:

- Natural, traditional material
- Long-lasting, breathable, high-quality
- Can be eco-friendly if responsibly processed

Challenges:

- Environmental impact of tanning
- Hazardous substances if not regulated

Recycled Plastics in Footwear

♻️ **Source: Derived from post-consumer PET bottles, textile waste, and discarded plastics**

🌍 Environmental benefits:

- Reduces plastic waste and landfill pressure
- Decreases reliance on virgin fossil-based materials
- Requires lower energy consumption compared to virgin polyester production

👟 Applications in footwear:

- Uppers, linings, insoles, laces

📈 Market trend:

Recycled polyester now makes up ~15 % of global polyester fibre market (Textile Exchange 2025)

Challenges:

- Downcycling risk: limited fibre strength after multiple recycling cycles
- Microplastic shedding during washing/use
- Dependence on effective collection and recycling

Recycled Plastics in Foot

♻️ Concept: Old sneakers are collected, dismantled, and re-processed into new materials for footwear production.

🌍 Environmental benefits:

- Reduces landfill waste and incineration
- Cuts demand for virgin raw materials
- Demonstrates practical application of the circular economy

👟 Brand examples:

- Nike “Grind” program – recycled outsoles and midsoles
- Adidas collaborations with recycling initiatives

Challenges:

- Complex dismantling due to mixed materials (rubber, EVA, leather, textiles, adhesives)
- High costs and limited large-scale infrastructure
- Need for design-for-disassembly to improve recyclability

🔄 Circular design in action:

Extends product life by transforming waste into

Vegan Leathers: Overview

Definition	Key Features	Market Note	Challenges
▪ Plant-based or synthetic alternatives to animal leather ▪ Aim: reduce reliance on animal hides and toxic tanning processes	▪ Derived from agricultural waste or bio-based polymers ▪ Often biodegradable or recyclable, depending on composition ▪ Applications: uppers, linings, bags, and accessories ▪ Growing interest from fashion and footwear brands seeking cruelty-free options	▪ Rising demand driven by younger, eco-conscious consumers ▪ Supported by EU regulations promoting sustainable material innovation	▪ Cost and scalability compared to conventional leather ▪ Durability and performance variation between types ▪ Some “vegan” leathers still rely on PU/PVC blends (petroleum-based)

Vegan Leathers: Examples

Cactus Leather

- Made from Nopal cactus leaves
- Durable, flexible, partially biodegradable

Apple Leather

- Produced from apple waste (peels, cores)
- Smooth texture, commonly used in fashion accessories

Cork Leather

- From compressed cork bark
- Lightweight, water-resistant, natural aesthetic

Algae-based Materials

- Derived from algae biomass
- Innovative option for foams and flexible textiles

⚠ Note on PU/PVC

- Many vegan leathers use Polyurethane or PVC backings
- Raises concerns about recyclability and fossil-fuel dependence

Recycled Plastics in Footwear

♻️ **Source: Derived from post-consumer PET bottles, textile waste, and discarded plastics**

🌍 Environmental benefits:

- Reduces plastic waste and landfill pressure
- Decreases reliance on virgin fossil-based materials
- Requires lower energy consumption compared to virgin polyester production

👟 Applications in footwear:

- Uppers, linings, insoles, laces

📈 Market trend:

Recycled polyester now makes up ~15 % of global polyester fibre market (Textile Exchange 2025)

Challenges:

- Downcycling risk: limited fibre strength after multiple recycling cycles
- Microplastic shedding during washing/use
- Dependence on effective

Mushroom Leather: Mycelium

Overview

- Produced from the root system of fungi (*mycelium*)
- Cultivated in controlled environments using agricultural waste as feedstock

Challenges

- High production costs at current scale
- Durability testing still ongoing compared to conventional leather

Key Benefits

- 🌱 100 % biodegradable and compostable
- ⚡ Low-energy, low-water production process
- 👟 Suitable for footwear uppers, linings, and accessories
- 💡 Texture and look similar to animal leather

Market & Innovation

- Brands like MycoWorks and Bolt Threads developing scalable solutions
- Increasing investment from luxury fashion and footwear companies
- Seen as one of the most promising next-gen materials

Pineapple Leather (Piñatex)

Overview

- Developed from fibres extracted from pineapple leaves (agricultural by-product)
- Commercially known as *Piñatex*

Market & Adoption

- Supported by partnerships with major footwear and fashion brands
- Expanding use in mainstream collections, not just niche markets

Key Benefits

- 🍍 Utilizes agricultural waste → reduces landfill burning of leaves
- 🌱 Lightweight, breathable, and flexible
- 👟 Used in footwear, bags, and accessories (e.g., sneakers, sandals)
- 🥊 Cruelty-free alternative to animal leather

Challenges

- Durability lower than high-quality animal leather
- Often backed with resins (sometimes petroleum-based) to improve strength
- Scaling up production while keeping costs competitive

Innovative Fibres for Footwear

Seacell

- Made from seaweed + cellulose
- Soft, breathable, with antioxidant properties

SoySilk

- Soy Protein Fibre
- By-product of soy food industry
- Soft, durable, moisture-regulating

Lyocell

- Derived from Wood Pulp
- High absorbency, biodegradable

Nettle Fibre

- Traditional European fibre, naturally strong
- Requires little pesticide or fertilizer, eco-friendly

Applications

- Blended into uppers, linings, and textiles
- Provide unique performance and sustainability features

Market Trends

Global Picture

- 🌱 Sustainable fibres gaining market share:
  - Organic cotton → ~706k tonnes (2.9 % of global cotton, 2023/24)
  - Recycled polyester → ~15 % of total polyester market
- 🌍 Growing demand for **next-gen materials** (cactus, mushroom, pineapple, algae-based leathers)

Drivers of Growth

- EU Green Deal & Eco-Design **regulation** accelerating material innovation
- Consumer awareness shifting towards **eco-certified products**
- Brands investing in **closed-loop systems** (recycling, take-back programs)

Investment Trends

- Major footwear brands scaling up partnerships with material startups
- Venture capital moving into biomaterials and circular textiles
- Supply chain transparency (blockchain, digital product passports) becoming a

Regulations in the EU a drivers

Regulations for Biodegradable & Recyclable Materials in Footwear & Leather Goods

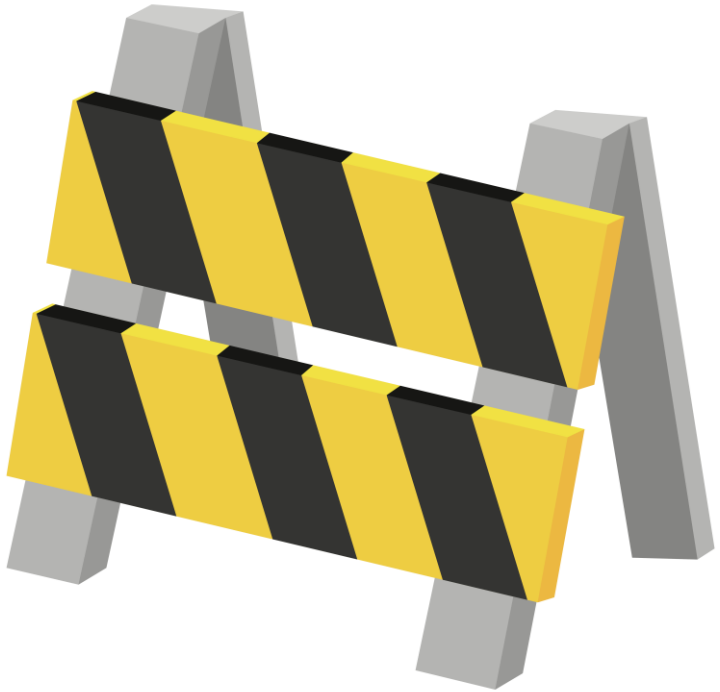
- **EU Ecodesign for Sustainable Products Regulation (ESPR)**
  - Sets performance & information requirements for textiles, footwear, leather.
  - Digital Product Passport for traceability & consumer transparency.
- **EU Waste Framework Directive (2008/98/EC)**
  - Mandatory **separate collection of textile waste by 2025.**
  - Encourages **Extended Producer Responsibility (EPR)** for footwear & leather.
- **Extended Producer Responsibility (EPR) Schemes**
  - Producers must manage products across their lifecycle (design → disposal).
  - France pioneered EPR for textiles & footwear (since 2007).
- **National Circular Economy Plans (MED Countries)**
  - Spain: PERTE Circular Economy (€195M) supports sustainable footwear, textiles, plastics.
  - Italy: Early mandatory textile waste separation (2022, ahead of EU 2025 deadline).
  - Bulgaria: Draft regulation on footwear & textile waste under development.
- **Green Claims Regulation (2023)**
  - Companies must **substantiate environmental claims** (e.g., "biodegradable leather") with verifiable data.

Designed

Consumer Demand

- Growing preference for **eco-certified products** (GOTS, EU Ecolabel, OEKO-TEX)
- Younger generations driving demand for **cruelty-free and vegan footwear**
- Transparency and traceability increasingly valued (QR codes, blockchain)
- Market surveys show willingness to pay more for sustainable options (?)

Key Barriers in Sustainable Materials



Raw material availability

- Seasonal yields, regional dependence (e.g., cotton, natural rubber)
- Climate change impacts on crops and forests

Cost & Scalability

- Higher production costs than conventional materials
- Difficulties scaling bio-based innovations to mass market

Performance Trade-offs

- Durability and quality inconsistencies compared to traditional leather & synthetics
- Need for advanced testing and certifications

Recycling Infrastructure

- Lack of global systems for large-scale collection and processing
- Downcycling risks limit circularity

Market Adoption

Summary: Key Sustainable Material Options

Organic & Natural Materials

- Cork
- organic cotton
- natural rubber
- hemp
  responsibly sourced leather

Recycled Materials

- PET bottles → polyester yarns
- Recycled sneakers

Vegan & Next-Gen Alternatives

- Cactus
- apple
- pineapple (Piñatex)
- mushroom (mycelium)
- algae

Innovative Fibres

- Seacell (seaweed)
- Lenpur (wood pulp)
- SoySilk
- Nettle

Takeaway

- Sustainable design begins with material choices
- No single “perfect” material → every option has trade-offs
- Combining circular strategies (reduce, reuse, recycle) strengthens impact
- Innovation, regulation, and consumer demand are accelerating the shift
- Designers have a key role: to create products that are eco-responsible, functional, and appealing

Designed by Freepik