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2021-1-TR01-KA220-VET-000028186

FOOTWEAR DESIGN

FOR THE CIRCULAR ECONOMY

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Co-funded by the European Union

PERFORMANTICA Publishing House
Iasi, Romania, 2025
ISBN 978-630-328-141-4

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FOOTWEAR DESIGN FOR THE CIRCULAR ECONOMY

BOOK OF LECTURES

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TABLE OF CONTENTS

MODULE 1
CIRCULAR ECONOMY IN THE FOOTWEAR INDUSTRY –LEGISLATION, CONCEPTS AND PRINCIPLES

BY **SPYROS BOFYLATOS, NIKI BOUKOUVALA** AND **PHILIP AZARIADIS**
UNIVERSITY OF THE AEGEAN

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LECTURE 1
ENVIRONMENTAL LEGISLATION AND STANDARDS

1.1. INTRODUCTION

Overview of the footwear industry and its environmental impact

The footwear industry plays a significant role in global consumerism, providing a wide range of shoes to meet the demands of fashion-conscious consumers worldwide. However, the environmental impact of the footwear industry is increasingly concerning. From the extraction of raw materials to manufacturing processes and product disposal, each stage of the footwear lifecycle presents environmental challenges.

One major environmental issue associated with the footwear industry is the extraction of raw materials. The production of materials such as leather, rubber, and synthetic fabrics requires significant amounts of land, water, and energy. The leather industry, for instance, contributes to deforestation as it drives the expansion of livestock farming for leather production. Similarly, the production of synthetic materials involves the use of petroleum-based chemicals, further contributing to resource depletion and greenhouse gas emissions.

Moreover, the manufacturing processes involved in footwear production have a considerable environmental impact. Energy-intensive processes, such as cutting, sewing, and assembling shoes, contribute to carbon emissions and air pollution. Chemical usage, including dyes, adhesives, and finishes, poses a threat to water sources and ecosystems due to improper disposal and runoff. Additionally, the transportation of materials and finished products across the globe increases the industry's carbon footprint.

Another significant concern is the disposal of footwear. With ever-changing fashion trends and a "throwaway" culture, shoes often end up in landfills, where they can take decades to decompose. The materials used in footwear, particularly synthetic components, do not break down easily and may release harmful substances into the environment over time.

To address these environmental challenges, various approaches are being taken within the footwear industry. Sustainable material sourcing, such as using organic or recycled materials, aims to reduce the industry's reliance on resource-intensive materials. Innovations in manufacturing processes, such as water-based adhesives and energy-efficient technologies, aim to minimize carbon emissions and chemical usage. Additionally, the concept of circular economy is gaining traction, promoting the recycling and upcycling of shoes to reduce waste and extend their lifespan.

Consumers also play a crucial role in mitigating the environmental impact of the footwear industry. By making conscious choices and supporting sustainable and ethical footwear brands, consumers can

encourage the adoption of more environmentally friendly practices. Additionally, proper shoe care and repair can help extend the lifespan of shoes, reducing the need for frequent replacements.
In conclusion, the footwear industry's environmental impact is a growing concern due to its resource-intensive processes, chemical usage, and disposal practices. However, the industry is taking steps towards sustainability through responsible material sourcing, innovative manufacturing techniques, and embracing the principles of the circular economy. To achieve meaningful change, collaboration between industry stakeholders, policymakers, and consumers is necessary. By making informed choices and supporting sustainable practices, we can collectively reduce the environmental footprint of the footwear industry and promote a more environmentally responsible approach to footwear production and consumption.

Importance of environmental legislation and standards

Environmental legislation and standards play a crucial role in the footwear industry, ensuring that environmental impacts are mitigated, sustainability is prioritized, and responsible practices are followed. As one of the largest industries globally, the footwear sector has the potential to exert significant influence on the environment and human well-being. Environmental legislation and standards provide a framework to address these impacts and drive positive change.
Firstly, environmental legislation sets legal requirements and guidelines that companies must adhere to in order to protect the environment. These regulations encompass a range of aspects, including waste management, chemical usage, emissions control, and resource conservation. By enforcing these laws, governments can hold companies accountable for their environmental practices and encourage the adoption of sustainable measures. Compliance with environmental legislation ensures that the footwear industry minimizes its negative impact on ecosystems, reduces pollution, and conserves natural resources.
Furthermore, environmental standards provide industry-specific guidelines and benchmarks for sustainable practices. Standards, such as ISO 14001 [1](Environmental Management Systems) and the Sustainable Apparel Coalition's Higg Index[2], offer frameworks for companies to assess and improve their environmental performance. These standards cover areas like energy efficiency, water usage, waste reduction, and supply chain transparency. By adhering to environmental standards, footwear companies can demonstrate their commitment to sustainability, enhance their credibility, and align with best practices.
Environmental legislation and standards also promote innovation and the development of environmentally friendly technologies within the footwear industry. As companies strive to meet regulatory requirements and achieve compliance with standards, they are motivated to invest in research and development of cleaner production methods, sustainable materials, and recycling

[1] https://www.iso.org/iso-14001-environmental-management.html
[2] https://apparelcoalition.org/the-higg-index/

technologies. This focus on innovation drives industry-wide improvements and fosters the creation of more sustainable footwear products.

Moreover, environmental legislation and standards help level the playing field among industry players. By setting minimum requirements and expectations, they create a fair and competitive environment where companies cannot gain a competitive advantage through environmentally harmful practices. This encourages companies to embrace sustainable practices, driving positive change across the industry as a whole.

In conclusion, environmental legislation and standards are crucial for the footwear industry to address its environmental impact, promote sustainability, and foster responsible practices. By establishing legal requirements, guidelines, and industry-specific benchmarks, they ensure that companies operate in an environmentally responsible manner. Compliance with these regulations and standards helps minimize pollution, conserve resources, and drive innovation. Moreover, they create a fair competitive landscape and provide consumers with the assurance that their footwear purchases align with environmental values. Environmental legislation and standards are essential tools in shaping the future of the footwear industry, enabling it to become more sustainable and environmentally conscious.

1.2. ENVIRONMENTAL CHALLENGES IN THE FOOTWEAR INDUSTRY

Overview of environmental challenges specific to the footwear industry

The footwear industry has substantial impacts on ecosystems, natural resources, and human well-being. Recognizing and addressing these environmental concerns are paramount for the industry's progression towards more sustainable practices and the reduction of its ecological footprint.

One prominent challenge resides in the extraction and **processing of raw materials**. Leather, a widely utilized material in footwear, originates from the livestock sector, which contributes to deforestation and water contamination. The utilization of synthetic textiles, derived from petroleum-based sources, engenders carbon emissions and resource depletion. Furthermore, manufacturing processes entail the deployment of chemicals, energy-intensive machinery, and the generation of waste, thereby amplifying air and water pollution.

An additional significant challenge arises in the **disposal of footwear waste**. The materials employed in footwear production, such as rubber soles and synthetic textiles, possess protracted decomposition periods within landfills, fostering the accrual of waste. Improper disposal practices, encompassing incineration and landfilling, release deleterious chemicals and greenhouse gases, thereby exacerbating environmental degradation.

The industry further confronts challenges pertaining to transportation. **Globalized supply chains** often necessitate the long-distance conveyance of materials and finished products, resulting in escalated energy consumption and carbon emissions. Additionally, packaging of footwear products engenders waste production and contributes to the overall environmental impact.

Moreover, the footwear industry impacts water resources through its water-intensive manufacturing processes and the contamination of water bodies resulting from chemical usage and waste disposal. To mitigate these challenges, the footwear industry is increasingly embracing sustainable practices. These encompass the adoption of eco-friendly materials, such as organic cotton and recycled polyester, as well as the exploration of alternative manufacturing processes that curtail resource consumption and waste generation. Additionally, initiatives focused on recycling and upcycling footwear waste are gaining momentum, aiming to diminish the industry's environmental footprint.

In conclusion, the footwear industry confronts a multitude of environmental challenges associated with raw material extraction, manufacturing processes, waste management, and transportation. By embracing sustainable practices, adhering to circular economy principles, and implementing responsible waste management strategies, the industry can endeavor to mitigate its environmental impact and contribute to the realization of a more sustainable future.

Impact of footwear waste and disposal methods

The issue of footwear waste poses significant environmental challenges. Each year, vast quantities of shoes end up in landfills or incinerators. The materials used in footwear, including rubber soles, synthetic textiles, and adhesives, can take decades or even centuries to decompose, leading to long-term environmental consequences.

Furthermore, improper disposal methods, such as burning or landfilling, can release harmful chemicals and greenhouse gases into the environment. The incineration of shoes contributes to air pollution and the release of toxic substances, while landfilling results in the accumulation of waste and the potential leaching of hazardous materials into the soil and water systems.

To address these challenges, it is important to explore sustainable disposal methods and promote circular economy principles in the footwear industry. Recycling and upcycling programs can help reduce the environmental impact of footwear waste. Companies can collaborate with recycling facilities to collect and repurpose old shoes, turning them into new products or materials for other industries. Promoting extended producer responsibility can also encourage manufacturers to take responsibility for the end-of-life management of their products, fostering a more sustainable approach to disposal.

In conclusion, the footwear industry faces significant environmental challenges throughout the production process. Understanding the environmental footprint of footwear production, including the extraction of raw materials and manufacturing processes, is essential to drive positive change. Additionally, addressing footwear waste and promoting sustainable disposal methods are crucial steps towards reducing the industry's environmental impact. By adopting sustainable practices, embracing circular economy principles, and promoting responsible waste management, the footwear industry can contribute to a more environmentally sustainable future.

1.3. INTERNATIONAL ENVIRONMENTAL LEGISLATION AND AGREEMENTS

Overview of key international agreements related to the environment

International legislation, particularly within the European Union (EU), plays a significant role in shaping the practices and environmental impact of the footwear industry. EU law provides a framework that sets standards, requirements, and guidelines for companies operating within its member states. The relevance of international legislation, particularly EU law, to the footwear industry can be seen in several key aspects.

Firstly, EU legislation establishes environmental standards and regulations that companies must comply with. The EU places a strong emphasis on sustainability and has implemented various directives and regulations that directly impact the footwear industry. For instance, regulations such as **REACH** (Registration, Evaluation, Authorization, and Restriction of Chemicals)[3] impose strict rules on chemical usage, ensuring the safety of both consumers and the environment. Additionally, the EU Ecolabel[4] provides a voluntary certification scheme that promotes the use of environmentally friendly materials and production methods.

Furthermore, EU legislation supports transparency and supply chain responsibility in the footwear industry. The **EU Timber Regulation** prohibits the trade of illegally harvested timber, which indirectly affects the sourcing of materials such as leather in the footwear sector. The EU also requires companies to disclose information on the origin and environmental impact of their products through regulations like the **Non-Financial Reporting Directive**[5]. These measures aim to enhance accountability and encourage sustainable practices throughout the supply chain.

Moreover, EU legislation promotes circular economy principles, which are particularly relevant to the footwear industry's environmental challenges. The **EU Waste Framework Directive**[6] and the **Circular Economy Action Plan**[7] set targets and guidelines for waste management, recycling, and resource efficiency. By encouraging sustainable product design, promoting recycling initiatives, and minimizing waste generation, EU legislation contributes to reducing the environmental footprint of the footwear industry.

In conclusion, international legislation, especially within the EU, is highly relevant to the footwear industry's environmental practices. EU law establishes standards, requirements, and regulations that companies must adhere to, promoting sustainability, transparency, and supply chain responsibility. By setting guidelines for chemical usage, promoting transparency, and encouraging circular economy

[3] https://environment.ec.europa.eu/topics/chemicals/reach-regulation_en
[4] https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel/about-eu-ecolabel_en
[5] http://data.europa.eu/eli/dir/2014/95/oj
[6] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en
[7] https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

principles, EU legislation plays a crucial role in driving positive environmental change and shaping the future of the footwear industry towards a more sustainable and responsible direction.

Examination of specific laws and regulations relevant to the footwear industry

The footwear industry holds a significant position in the global economy, yet its environmental impact necessitates attention to resource consumption, energy use, and waste generation. In recent years, the European Union (EU) has placed increasing emphasis on integrating circular economy principles and promoting sustainability within the footwear sector. Let us examine the specific laws and regulations that pertain to this industry in the EU context.

1. Product Design and Waste Management: The **EU's Waste Framework Directive (2008/98/EC) and Circular Economy Action Plan** outline regulations crucial to the footwear industry. These laws stress waste prevention, reuse, and recycling. Manufacturers are encouraged to adopt design strategies that prolong product lifespan, facilitate repair and maintenance, and enable the recovery of materials at the end of their life cycle. Compliance with these sustainable product design principles enables the footwear industry to reduce waste and promote circularity legally.
2. Chemicals and Restricted Substances: The **Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH)** Regulation (EC 1907/2006) plays a fundamental role in the EU footwear industry. REACH aims to ensure the safe use of chemicals throughout the supply chain. Manufacturers must comply with restrictions on hazardous substances such as heavy metals, phthalates, and specific allergenic dyes. Adherence to these regulations minimizes the environmental and health risks associated with chemical usage, ensuring legal compliance.
3. Extended Producer Responsibility (EPR): The EU's **Extended Producer Responsibility** (EPR) framework (Directive 2008/98/EC) places responsibility on the footwear industry to manage the post-consumer phase of its products. Manufacturers and importers must establish systems for the collection, recycling, and appropriate disposal of footwear waste. EPR schemes incentivize producers to adopt more sustainable practices while encouraging the development of recycling infrastructure. By participating in these legally required schemes, the footwear industry contributes to the circular economy by reducing waste and promoting resource efficiency.
4. Energy Efficiency and Carbon Footprint: The EU has established various regulations to promote energy efficiency and reduce the carbon footprint of industries, including the footwear sector. These regulations encompass energy labelling requirements**, eco-design standards** (Regulation 2019/2011), and emissions reduction targets (Effort Sharing Regulation)[8]. The footwear industry can legally contribute to sustainability goals by adopting

[8] https://climate.ec.europa.eu/eu-action/effort-sharing-member-states-emission-targets/effort-sharing-2021-2030-targets-and-flexibilities_en

energy-efficient manufacturing processes, utilizing renewable energy sources, and reducing greenhouse gas emissions.

5. Supply Chain Transparency and Social Responsibility: The EU places strong emphasis on supply chain transparency and social responsibility. Legislation such as the **Conflict Minerals Regulation** (Regulation 2017/821) and the Modern Slavery Act requires companies to disclose information about the origins of raw materials and ensure fair labor practices throughout their supply chains. Complying with these regulations combats unethical practices and promotes sustainable sourcing, ensuring legal and ethical operations within the footwear industry.
6. Voluntary Initiatives and Certifications: In addition to legal requirements, the footwear industry in the EU can voluntarily participate in initiatives and certifications that demonstrate their commitment to sustainability. Examples include the **Global Organic Textile Standard** (GOTS) for organic footwear materials, the **Leather Working Group (LWG) certification** for responsible leather production, and various eco-labels that verify a product's environmental performance. These voluntary initiatives provide additional credibility and market advantage for companies operating sustainably, complementing legal obligations.

As the demand for sustainable products grows, compliance with these laws and regulations becomes increasingly crucial for the footwear industry in the EU. By integrating circular economy principles, adopting sustainable design practices, managing waste responsibly, reducing chemical use, and promoting supply chain transparency, the industry can legally contribute to a more sustainable and environmentally friendly future.

Compliance challenges and best practices for footwear manufacturers

Compliance with regulations and standards poses significant challenges for footwear manufacturers in the European Union (EU). The complex and evolving nature of environmental, health, and safety regulations requires manufacturers to stay updated and ensure adherence to legal requirements. Some compliance challenges include navigating the intricacies of chemical regulations, such as REACH, and managing the proper disposal of hazardous waste generated during production processes. Additionally, ensuring supply chain transparency and responsible sourcing of materials can be challenging due to the global nature of the industry.

To overcome these challenges, footwear manufacturers can adopt best practices. Implementing robust internal systems and processes to monitor and manage compliance is crucial. This includes conducting regular audits, documentation of processes, and staff training to ensure awareness of regulatory requirements. Collaboration with suppliers and stakeholders can facilitate responsible sourcing and transparency throughout the supply chain. Engaging with industry associations and staying informed about changes in regulations enables manufacturers to proactively adapt their practices.

Furthermore, leveraging technology and software solutions can streamline compliance management by automating data collection, analysis, and reporting. Seeking third-party certifications and labels, such as the EU Ecolabel, can demonstrate a commitment to sustainable practices and compliance with environmental standards.

In conclusion, compliance challenges for footwear manufacturers in the EU require careful attention and proactive measures. By implementing robust internal systems, fostering supply chain transparency, and leveraging technology, manufacturers can navigate the complex landscape of regulations and ensure compliance with environmental, health, and safety standards. Embracing best practices not only ensures legal compliance but also promotes sustainability and responsible manufacturing in the footwear industry.

Overview of emerging environmental legislation and trends in the footwear industry

In recent years, the footwear industry has witnessed a growing focus on sustainability and environmental responsibility. This shift is largely driven by emerging environmental legislation and increasing consumer demand for eco-friendly products. Let's explore some key trends and legislation shaping the future of the footwear industry.

One prominent trend is the increasing use of eco-friendly materials in footwear design. From recycled plastics to bio-based alternatives, manufacturers are exploring sustainable options that reduce the industry's reliance on non-renewable resources. Additionally, the concept of circular economy is gaining traction, prompting companies to develop innovative solutions for recycling and upcycling shoes at the end of their lifecycle.

To support these sustainability efforts, environmental legislation is being implemented. The European Union's Green Deal and Circular Economy Action Plan are driving transformative changes in the footwear industry. These initiatives emphasize the importance of extended producer responsibility, waste reduction, and sustainable design practices. Footwear companies will need to comply with stricter regulations regarding material usage, chemical management, and carbon footprint.

Discussion on technological advancements and innovations for sustainable footwear production

Technological advancements are transforming the landscape of sustainable footwear production, offering innovative solutions that reduce environmental impact and improve efficiency. These advancements are revolutionizing the way shoes are designed, manufactured, and even recycled. Let's explore some key developments in this area.

One notable technological advancement is the use of 3D printing in footwear design and production. 3D printing allows for precise and customizable manufacturing, reducing material waste and enabling more sustainable production processes. This technology offers the ability to create intricate and complex shoe designs with optimized material usage. Designers can experiment with various shapes, textures, and structures, leading to unique and innovative footwear creations. Additionally, 3D printing enables on-demand production, eliminating the need for excessive inventory and reducing waste from overproduction.

Digital design tools and virtual prototyping are also transforming the footwear design process. These tools allow designers to create and visualize shoe designs digitally before physical prototypes are produced. Virtual prototyping eliminates the need for multiple physical samples, reducing material waste and accelerating the design iteration process. It enables designers to make informed decisions about the materials and manufacturing techniques that will be used, optimizing sustainability considerations from the early stages of product development.

Innovations in materials are also shaping the future of sustainable footwear production. Plant-based materials are gaining prominence as eco-friendly alternatives to traditional leather. For example, pineapple leaf fibers, known as Piñatex, are a byproduct of the pineapple industry and can be used as a leather substitute. Piñatex has similar properties to genuine leather, offering durability and texture, but with a significantly lower environmental impact. Similarly, mushroom leather, also known as Mylo, is derived from mycelium, the root structure of mushrooms. Mylo provides a sustainable and cruelty-free alternative to animal-based leather, reducing the industry's reliance on animal products while offering a material that is versatile and renewable.

Furthermore, Non-Fungible Tokens (NFTs) are emerging as a transformative technology that has the potential to revolutionize the fashion industry. NFTs are unique digital assets that can represent ownership or proof of authenticity of a digital or physical item. In the context of fashion, NFTs can be used to verify the authenticity and provenance of luxury items, ensuring consumers that they are purchasing genuine products. NFTs also enable designers and creators to tokenize their digital fashion creations, allowing for new opportunities in the digital fashion space. By owning NFT-based digital fashion items, consumers can express their individuality and style in virtual environments or even in augmented reality experiences. This technology not only offers a new way to engage with fashion but also opens up possibilities for limited editions, collaborations, and unique digital fashion experiences. However, it's important to consider the environmental impact of NFTs due to their energy consumption. As the fashion industry continues to explore the potential of NFTs, it is crucial to address these environmental concerns and find sustainable solutions that minimize their carbon footprint.

Anticipated changes in environmental legislation and their implications for the industry

As the importance of sustainability continues to grow, it is anticipated that environmental legislation will become more stringent and comprehensive, with implications for the footwear industry. Companies need to anticipate these changes and proactively align their practices to meet future requirements. Here are some anticipated changes in environmental legislation and their implications:

- Chemical Restrictions: There will likely be increased scrutiny on chemical usage in footwear production. Restrictive regulations such as REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) will continue to evolve, placing stricter controls on the use of hazardous substances. Footwear companies will need to embrace safer and greener alternatives, ensuring compliance with chemical regulations and promoting the use of environmentally friendly materials.

- Supply Chain Transparency: Transparency throughout the supply chain will be a significant focus. Consumers are demanding greater visibility into the origin of materials, production processes, and labor conditions. Companies will need to implement robust supply chain management systems, ensuring traceability, responsible sourcing, and fair labor practices. This transparency will enhance consumer trust and enable informed purchasing decisions.
- Carbon Footprint Reduction: With the increasing emphasis on combating climate change, carbon footprint reduction will be a priority. Companies will need to implement measures to track and reduce their greenhouse gas emissions throughout the entire value chain. This includes adopting energy-efficient manufacturing processes, utilizing renewable energy sources, and optimizing logistics and transportation.
- Circular Economy Approach: The circular economy will gain more prominence, necessitating a shift from a linear "take-make-dispose" model to one that promotes recycling and waste reduction. Companies will be expected to develop strategies for product durability, repairability, and end-of-life management. Implementing take-back programs and exploring innovative recycling and upcycling methods will become essential.

Adapting to these anticipated changes in environmental legislation will require strategic planning and a commitment to sustainable practices. Companies that proactively embrace these changes will not only ensure compliance but also position themselves as leaders in the industry, meeting consumer expectations for sustainable and responsible footwear manufacturing. By integrating technological advancements, embracing sustainable materials, and aligning with future environmental regulations, the footwear industry can play a significant role in shaping a more sustainable future.

LECTURE 2
CIRCULAR ECONOMY PRINCIPLES IN FOOTWEAR DESIGN: CREATING SUSTAINABLE AND CIRCULAR FOOTWEAR

2.1. UNDERSTANDING THE CIRCULAR ECONOMY

Explanation of the Principles and Concepts of the Circular Economy

The circular economy is a revolutionary approach to economic and industrial systems that aims to decouple economic growth from resource consumption. Unlike the traditional linear economy, which follows a "take, make, dispose" pattern, the circular economy emphasizes sustainability, resource efficiency, and waste reduction. At its core, this concept revolves around the preservation and regeneration of resources throughout the entire product life cycle.

Closed-Loop Systems: The circular economy encourages closed-loop systems, wherein products and materials are continuously reused, refurbished, remanufactured, or recycled. By keeping products and materials within the economy for as long as possible, waste generation is minimized, and valuable resources are retained.

Product Life Extension: Extending the life of products through maintenance, repair, and refurbishment is central to the circular economy. This approach not only reduces waste but also fosters the development of innovative business models, such as product-as-a-service, which encourages manufacturers to design durable and long-lasting products.

Biomimicry and Regenerative Design: The circular economy draws inspiration from nature's design principles, promoting regenerative approaches that mimic natural ecosystems. By adopting regenerative design principles, businesses can create products and systems that have a positive impact on the environment and promote biodiversity.

Collaborative Consumption: Encouraging sharing and collaborative consumption models can significantly reduce individual ownership and resource demand. Platforms that facilitate sharing or renting of products, such as footwear, can optimize resource utilization and minimize waste.

Sustainable Materials: Emphasizing the use of renewable, biodegradable, and non-toxic materials ensures that products have a minimal environmental footprint. This shift promotes the incorporation of eco-friendly materials in footwear design, making them easier to recycle and recover at the end of their life.

From a Linear to a Circular Footwear Design Model

The footwear industry has long operated under a linear design model, characterized by high resource consumption, short product lifespans, and considerable waste generation. However, with growing awareness of environmental challenges, there is a pressing need for the industry to embrace circular economy principles in its design and production processes.

Design for Durability: Adopting circular design principles entails creating footwear that is durable, repairable, and upgradeable. By using high-quality materials and construction techniques, footwear can withstand extended use and be easily repaired, extending their lifespan.

Take-Back Initiatives: Footwear companies can implement take-back initiatives, where they accept used products from customers and ensure their proper recycling or refurbishment. This allows companies to reclaim valuable materials and incentivizes customers to participate in circular practices.

Material Innovation: Developing and utilizing sustainable and recyclable materials is fundamental to transitioning to a circular footwear model. Companies can explore alternatives to traditional shoe materials, such as biodegradable or bio-based options, to reduce environmental impact.

Circular Business Models: Embracing new business models like leasing or subscription services for footwear can shift the focus from ownership to access. This encourages manufacturers to create products that last longer and are easier to maintain, reducing waste and resource consumption.

Benefits and Opportunities of Adopting Circular Economy Principles in Footwear Design

Reduced Environmental Impact: Embracing circular economy principles in footwear design significantly reduces the industry's environmental footprint. By prolonging product life, minimizing waste, and promoting sustainable materials, the industry can mitigate its impact on ecosystems, biodiversity, and climate change.

Enhanced Resource Efficiency: Circular footwear design optimizes resource utilization by promoting the reuse and recycling of materials. This not only conserves valuable resources but also reduces the extraction of raw materials, lowering the industry's overall demand for natural resources.

Economic Opportunities: The transition to a circular economy in the footwear industry opens up new economic opportunities. Companies can develop innovative services and business models, create jobs in recycling and refurbishment, and establish profitable partnerships throughout the value chain.

Strengthened Brand Reputation: Consumers are increasingly demanding sustainable and eco-friendly products. Embracing circular economy principles can enhance a footwear brand's reputation, attract environmentally conscious customers, and foster loyalty and trust.

Long-Term Cost Savings: Circular design principles may require initial investment, but in the long run, they can lead to cost savings. Durable and repairable footwear reduces the need for frequent replacements, saving customers money and reducing manufacturing costs over time.

In conclusion, understanding and adopting circular economy principles in footwear design present a transformative opportunity for the industry. By transitioning from a linear to a circular model, the industry can create more sustainable products, reduce waste, and contribute to a healthier planet and economy. Embracing this shift requires collaboration between stakeholders, innovation in design and materials, and a shared commitment to building a circular and regenerative future for the footwear sector.

2.2. DESIGNING FOR DURABILITY AND LONGEVITY IN FOOTWEAR

Importance of Designing Footwear Products that are Durable and Long-Lasting

Designing footwear with durability and longevity in mind is of paramount importance for both consumers and the environment. In today's fast-paced consumer culture, there is a growing concern about the environmental impact of disposable and short-lived products. By creating durable and long-lasting footwear, designers can address these concerns while also benefiting their brand and consumers.

Environmental Impact: Footwear production consumes significant resources, including raw materials and energy. By designing products that last longer, the overall demand for new shoes decreases, reducing the environmental burden associated with manufacturing and waste disposal.

Waste Reduction: Footwear that quickly wears out contributes to the global waste problem. Designing for durability helps to reduce the amount of discarded shoes, leading to less waste in landfills and incinerators.

Consumer Satisfaction: Customers appreciate well-designed, durable footwear that withstands regular wear and tear. Creating products that maintain their quality over time leads to higher customer satisfaction and loyalty.

Cost-Effectiveness: While designing for durability may involve higher initial costs, it can save consumers money in the long run. Long-lasting shoes eliminate the need for frequent replacements, making them a cost-effective choice.

Strategies for Selecting High-Quality Materials and Components

The choice of materials and components significantly influences the durability and longevity of footwear. Designers can employ several strategies to ensure they select high-quality and durable materials.

Material Research: Thoroughly researching and understanding the properties of different materials is crucial. Opt for materials that are known for their strength, flexibility, and resistance to wear and tear.

Quality Testing: Conduct rigorous testing on potential materials to assess their durability and performance under various conditions. Consider abrasion resistance, tensile strength, and colorfastness, among other relevant factors.

Sustainable Materials: Whenever possible, opt for eco-friendly and sustainable materials that align with circular economy principles. Utilize recycled or bio-based materials that have a lower environmental impact.

Reinforced Components: Select components such as outsoles, midsoles, and uppers that are designed for durability. Reinforced stitching, sturdy heel counters, and durable glues can all enhance the overall longevity of the shoe.

Innovative Design Approaches to Enhance Product Lifespan and Promote Repairability

Innovative design approaches can significantly enhance the lifespan of footwear and promote repairability, extending their usability and reducing waste.

Modular Design: Adopt a modular design approach, where different components of the shoe can be easily replaced or repaired. For example, detachable insoles or interchangeable outsoles can increase the shoe's lifespan.

Stitching Techniques: Utilize robust and repairable stitching techniques that allow for easier repairs. Stitched constructions can often be more easily repaired compared to heavily glued ones.

Accessible Fastenings: Use easily accessible fastenings such as screws or snaps rather than permanent adhesives. This simplifies disassembly for repair and replacement purposes.

Repair Guides: Provide customers with repair guides or partner with repair services to make it easier for them to fix minor issues and extend the shoe's lifespan.

Customization: Design shoes that can be customized or personalized to suit the wearer's preferences. Personalized shoes are more likely to be cherished and cared for, leading to increased longevity.

In conclusion, designing footwear for durability and longevity is a pivotal step towards promoting sustainability in the footwear industry. By considering the environmental impact, utilizing high-quality materials, and embracing innovative design approaches, footwear designers can create products that benefit consumers, businesses, and the planet alike. Through collective efforts, the industry can shift towards a more responsible and sustainable future, where durable shoes not only meet fashion needs but also contribute to a circular and waste-conscious economy.

2.3. MATERIAL SELECTION AND CIRCULARITY IN FOOTWEAR DESIGN

Introduction to Sustainable Material Choices for Footwear Design

Sustainable material choices play a crucial role in the effort to create environmentally friendly and socially responsible footwear. As the demand for sustainable products rises, footwear designers have the opportunity to make a positive impact on the environment and society through their material selection.

Eco-friendly Materials: Eco-friendly materials are those that have a lower environmental impact compared to conventional materials. These can include organic cotton, hemp, bamboo, and other renewable plant-based fibers that require fewer pesticides and chemicals during cultivation.

Recycled Materials: Utilizing recycled materials, such as recycled PET (rPET) from plastic bottles or recycled rubber, helps to reduce the demand for virgin resources and decreases waste by repurposing existing materials.

Low-Impact Leather Alternatives: Leather production has significant environmental concerns due to the tanning process. Designers can explore alternatives like synthetic leather, mushroom leather (mycelium-based), or plant-based leather substitutes that offer similar aesthetics without the same environmental impact.

Bio-based Materials: Bio-based materials are derived from renewable resources and can include materials made from agricultural waste, such as pineapple leaf fibers (Piñatex) or apple leather, reducing the reliance on petroleum-based resources.

Eco-Friendly and Recycled Materials for Footwear Production

Recycled PET (rPET): Recycled PET, made from post-consumer plastic bottles, can be used to create shoe uppers, linings, and even outsoles. By repurposing plastic waste, designers can reduce environmental pollution and conserve energy compared to using virgin polyester.

Recycled Rubber: Recycled rubber, derived from discarded tires or manufacturing waste, is an excellent choice for outsoles. It helps reduce tire landfill waste and the need for new rubber extraction, making it an eco-friendly option.

Piñatex: Piñatex is a natural and sustainable material made from pineapple leaf fibers, a byproduct of the pineapple industry. This leather alternative offers a biodegradable option for shoe uppers, reducing the environmental impact compared to traditional leather.

EVA Foam Alternatives: Ethylene-vinyl acetate (EVA) foam is commonly used in shoe midsoles but is derived from petrochemicals. Eco-friendly alternatives, such as algae-based foams, provide similar cushioning properties while using renewable resources.

Recycled Textiles: Utilizing post-consumer recycled textiles, like recycled polyester or nylon, can reduce the environmental impact of footwear production and divert textiles from landfills.

Material Circularity, Recyclability, and Biodegradability

Incorporating circularity into footwear design involves considering the entire life cycle of the product, from sourcing and production to end-of-life disposal or regeneration.

Recyclability: Opt for materials that are easily recyclable or can be upcycled into new products at the end of the shoe's life. This encourages a closed-loop system, where materials can be continually reused, reducing the need for virgin resources.

Biodegradability: Select materials that are biodegradable, meaning they can naturally break down into harmless substances when discarded. Biodegradable materials reduce waste and have a lower environmental impact compared to materials that persist in the environment for extended periods.

Traceability: Ensure transparency and traceability of materials used in footwear production. Knowing the origins of materials allows designers to make informed choices and support ethical and sustainable sourcing practices.

Life Cycle Assessment: Conduct life cycle assessments to evaluate the environmental impact of materials throughout their entire life cycle, from raw material extraction to disposal. This helps identify areas for improvement and make more sustainable choices.

Collaboration and Recycling Infrastructure: Collaboration with other stakeholders, such as suppliers and recyclers, is essential to establish effective recycling infrastructure and closed-loop systems for footwear materials.

By thoughtfully selecting sustainable materials and embracing circular design principles, footwear designers can contribute to a more sustainable and responsible industry. By reducing resource consumption, waste generation, and environmental impact, they can shape a future where stylish and environmentally friendly footwear coexist harmoniously.

2.4. DESIGNING FOR DISASSEMBLY AND RECYCLING IN FOOTWEAR

Designing for Disassembly in Footwear Products

Designing for disassembly is a fundamental principle in the circular economy, focusing on creating products that can be easily taken apart and separated into their individual components at the end of their life. In the context of footwear, this approach involves considering the entire product life cycle and how shoes can be efficiently disassembled for recycling or refurbishment.

Modular Design: Adopting a modular design approach allows footwear to be composed of distinct and separable components. Shoes with removable insoles, detachable outsoles, and easily separable upper parts enable effortless disassembly.

Fastening Techniques: Using reversible and accessible fastening techniques, such as screws, snaps, or hooks, instead of permanent adhesives, makes it easier to disassemble shoes without damaging the components.

Standardization: Standardizing certain components across different shoe models simplifies the recycling and reuse processes. For instance, consistent sizing for insoles or outsoles allows interchangeability and facilitates recycling.

Marking and Identification: Employing clear markings or codes on components helps identify the materials used and provides guidance on disassembly, making recycling and material recovery more efficient.

Design Strategies to Facilitate Component Separation and Recycling

Designers can implement several strategies to ensure footwear products are designed for easy component separation and recycling:

Snap-Fit Connections: Incorporating snap-fit connections allows components to be securely attached while remaining easy to disassemble without the need for specialized tools.

Dissolvable Adhesives: Using dissolvable adhesives can aid in separating components during the recycling process, as they can be dissolved without causing damage to the materials.

Color-Coded Components: Employing a color-coding system for different components aids in identifying materials and facilitates their sorting and recycling at the end of the product's life.

Simplified Layering: Minimizing the number of layers in footwear design simplifies disassembly, as fewer materials need to be separated during recycling.

Material Compatibility: Choosing materials that have similar properties and can be processed together streamlines the recycling process and enhances the value of the recycled materials.

Case Studies Showcasing Successful Examples of Footwear Design for Disassembly

Adidas Futurecraft Loop: The Adidas Futurecraft Loop is a running shoe designed with a 100% recyclable TPU upper, which can be disassembled and reground into new shoe components without any material degradation. It utilizes no glue in the construction, and the different components are mechanically interlocked for easy disassembly.

Nike Grind: Nike Grind is a program that takes post-consumer and post-manufacture shoe waste and recycles it into various materials, including rubber, foam, and fabric. These materials are then used in the production of new shoes and other sports surfaces, promoting a closed-loop system.

Reebok Forever Floatride GROW: The Forever Floatride GROW is a running shoe from Reebok that embraces sustainability through a plant-based approach. It features a biodegradable sole made from castor bean oil, while the upper incorporates recycled polyester and natural rubber, making it more environmentally friendly and easier to disassemble.

Veja S.A. Sneakers: Veja, a French footwear brand, focuses on sustainability and transparency in its design and production processes. They use organic cotton, wild rubber from the Amazon rainforest, and other eco-friendly materials. The simple and minimalist design of their sneakers allows for easy disassembly and recycling of materials.

These case studies demonstrate how footwear brands are embracing the concept of designing for disassembly and recycling to create more sustainable products. By prioritizing modularity, recyclable materials, and simplified construction, designers can contribute to a more circular and resource-efficient footwear industry. This shift toward more disassemblable footwear not only benefits the environment but also aligns with consumer demands for products that have a positive impact on the planet.

2.5. INNOVATIVE MANUFACTURING TECHNIQUES FOR SUSTAINABLE FOOTWEAR PRODUCTION

Additive Manufacturing (3D Printing) and its Potential in Circular Footwear Design

Additive manufacturing, commonly known as 3D printing, has emerged as a promising technology in the footwear industry. It involves building objects layer by layer, allowing for precise customization and reducing material wastage. 3D printing holds considerable potential in circular footwear design for the following reasons:

Customization: 3D printing enables on-demand production and customization of footwear, catering to individual preferences and sizes. This personalization reduces excess inventory and eliminates the need for mass production.

Material Efficiency: Additive manufacturing uses only the necessary amount of material, resulting in minimal waste compared to traditional manufacturing processes, where excess material is often discarded.

Recyclability: Some 3D printing materials are recyclable, contributing to a closed-loop system. Recycled materials can be used to create new footwear products, further promoting sustainability.

Design Iteration: Designers can easily iterate and modify shoe designs digitally before printing the final product. This iterative process facilitates faster prototyping and reduces the need for physical samples, thus saving time and resources.

Localized Production: 3D printing can be decentralized, enabling localized production close to the end-users. This reduces transportation-related carbon emissions and supports local manufacturing ecosystems.

Other Emerging Manufacturing Techniques and Their Role in Circular Footwear Design

Apart from 3D printing, several other emerging manufacturing techniques contribute to circular footwear design:

Circular Knitting: Circular knitting machines produce seamless uppers, reducing waste and the need for additional stitching. This technique also allows for different yarn densities, enhancing breathability and comfort.

Direct Digital Manufacturing: Direct digital manufacturing techniques, such as laser cutting and CNC milling, enable precise production without generating excess material waste. These methods offer more sustainable alternatives for creating shoe components.

Biodegradable Materials: Advancements in biodegradable materials, like bioplastics and biodegradable textiles, present opportunities for sustainable footwear production. These materials can be utilized with innovative manufacturing techniques to create fully biodegradable shoes.

Sustainable Injection Molding: Injection molding techniques can incorporate sustainable materials, such as recycled plastics or bio-based resins, for creating shoe components like midsoles and outsoles.

Digital Foot Scanning: Digital foot scanning technologies enable accurate measurements, resulting in better-fitting shoes. Proper fit reduces returns and waste and ensures a longer product lifespan.

In conclusion, innovative manufacturing techniques offer exciting possibilities for sustainable footwear production. From 3D printing's customization and material efficiency to circular knitting's reduced waste, these technologies align with circular economy principles and pave the way for a more sustainable and environmentally conscious footwear industry. As these techniques continue to evolve, their integration with sustainable materials and circular design strategies will play a pivotal role in shaping the future of footwear manufacturing.

2.6. END-OF-LIFE STRATEGIES AND EXTENDED PRODUCT LIFE IN FOOTWEAR

Discussion on End-of-Life Strategies for Footwear Products

End-of-life strategies in footwear encompass the various approaches to handling shoes once they reach the end of their usable life. Traditional linear footwear models often lead to discarded shoes filling landfills, causing environmental harm. However, circular economy principles inspire innovative end-of-life strategies that aim to minimize waste and extend the product's lifespan.

Recycling: Recycling involves breaking down old shoes into their raw materials to create new products. Recycling facilities can recover materials like rubber, foam, textiles, and metals from discarded shoes for use in new shoe production or other applications.

Refurbishment and Repair: Implementing refurbishment and repair services encourages consumers to extend the life of their footwear. Manufacturers or third-party services can repair minor damages or replace worn-out components, such as outsoles or insoles, to keep shoes functional and wearable for longer.

Upcycling: Upcycling transforms old shoes or their components into entirely new products with added value. For example, turning old shoe soles into shoe molds, keychains, or decorative items repurposes materials and reduces waste.

Donations and Secondhand Sales: Donating or reselling gently used shoes allows them to have a second life with other consumers, reducing the need for new shoes and supporting circular consumption.

Exploring Opportunities for Product Reuse, Remanufacturing, and Upcycling

Reuse: Implementing reuse programs allows shoes to be collected, cleaned, and redistributed to those in need. Charitable organizations and shoe manufacturers can partner to create a closed-loop system where shoes are continually reused, promoting social and environmental benefits.

Remanufacturing: Remanufacturing involves disassembling worn-out shoes, cleaning the components, and remanufacturing them into "like-new" products. This process saves resources and reduces waste while offering consumers products with the same performance as new ones.

Upcycled Materials: Manufacturers can use upcycled materials to create new shoe components or even entirely new shoe lines. Utilizing upcycled textiles or rubber in the manufacturing process reduces the demand for virgin resources and promotes sustainable practices.

Circular Economy Partnerships: Collaboration between footwear brands and recycling or upcycling companies fosters circular business models. Brands can take back worn-out shoes, and recycling partners can process the materials, creating a closed-loop system for footwear production.

Examples of Circular Business Models that Extend the Product Life Cycle

Patagonia's Worn Wear: Patagonia's Worn Wear program encourages customers to trade in their used Patagonia products for store credit or buy and sell secondhand items. This initiative extends the life of products and reduces the environmental impact of manufacturing new items.

Nike's Reuse-A-Shoe Program: Nike's Reuse-A-Shoe program collects old athletic shoes and grinds them into material called Nike Grind. This material is then used in sport surfaces, such as tracks and playgrounds, and as cushioning in new Nike shoes.

Veja's Sneaker Refurbishment: French footwear brand Veja offers refurbishment services for their sneakers. Customers can send their worn-out Veja shoes for repair and refurbishment, extending the product's life and reducing waste.

Renting and Subscription Services: Some footwear brands are exploring renting or subscription models where customers can lease shoes for a limited period. After use, the shoes are returned, and the brand can refurbish or repair them for the next customer, increasing product life and reducing the need for new production.

By incorporating end-of-life strategies and embracing circular business models, footwear companies can contribute to a more sustainable industry. These practices not only reduce waste and resource consumption but also encourage consumers to make conscious and environmentally responsible choices. As circular economy principles continue to shape the footwear sector, the focus on extending product life and minimizing waste will lead to a more sustainable and socially beneficial future for the industry and the planet.

2.7. FUTURE TRENDS AND CHALLENGES IN CIRCULAR FOOTWEAR DESIGN

Future Trends in Circular Footwear Design

The future of circular footwear design holds exciting possibilities as the industry continues to innovate and embrace sustainable practices. Several trends and advancements are likely to shape the future of circular footwear design:

Advanced Sustainable Materials: Advancements in sustainable materials, such as biodegradable polymers, lab-grown leather, and mycelium-based materials, will offer designers more eco-friendly options for creating durable and biodegradable footwear.

Smart Design and Digitalization: Digital technologies like 3D scanning, AI-driven design, and virtual prototyping will enable more accurate and efficient footwear design, reducing material waste and improving product performance.

Circular Business Models: Circular business models, such as product-as-a-service, shoe leasing, and take-back initiatives, will gain popularity, encouraging greater product lifespan and resource efficiency.

Consumer Awareness and Education: Increasing consumer awareness of environmental issues will drive demand for sustainable and circular footwear, pushing brands to prioritize eco-friendly practices and transparency.

Blockchain Technology: Blockchain technology can enhance supply chain transparency, ensuring that sustainable materials are sourced ethically, and allowing customers to trace a shoe's journey from production to end-of-life.

Challenges and Barriers to Implementing Circular Economy Principles

While the shift towards circular footwear design presents numerous opportunities, it also comes with challenges and barriers that need to be addressed:

Design Complexity: Designing products for disassembly and recyclability can be more complex and costly, particularly during the transition from traditional linear practices to circular ones.

Supply Chain Integration: Implementing circular principles requires collaboration and alignment among various stakeholders in the footwear supply chain, including material suppliers, manufacturers, retailers, and recycling facilities.

Consumer Behavior: Convincing consumers to embrace circular consumption and opt for durable, repairable, and second-hand footwear can be challenging, especially in a market driven by fast fashion trends.

Limited Recycling Infrastructure: In some regions, there may be inadequate recycling facilities or technologies capable of processing certain footwear materials, hindering the closed-loop approach.

Scalability: Scaling circular practices to meet the demands of mass production and global markets can be daunting, requiring investment in infrastructure and technology.

Identifying Opportunities for Collaboration and Innovation in the Field

To overcome challenges and drive circular footwear design forward, collaboration and innovation are essential:

Partnerships: Footwear brands can collaborate with material suppliers, recycling companies, and NGOs to establish circular supply chains, share best practices, and accelerate the adoption of sustainable materials and practices.

Industry Standards: Creating industry-wide standards and certifications for circular footwear design will help guide companies in implementing sustainable practices and foster consumer trust.

Consumer Education: Raising awareness and educating consumers about the benefits of circular footwear and sustainable consumption can drive demand for more eco-friendly products.

Circular Design Competitions: Organizing design competitions focused on circular principles can incentivize innovation and creativity among designers, encouraging the development of sustainable and circular footwear concepts.

Research and Development: Investing in research and development of new materials, technologies, and manufacturing processes will drive continuous improvement and efficiency in circular footwear design.

Policy Support: Governments can play a crucial role by providing policy support, financial incentives, and regulations that encourage circular economy practices and reward sustainable initiatives in the footwear industry.

In conclusion, the future of circular footwear design is marked by innovation, sustainability, and collaboration. By embracing advanced sustainable materials, smart design technologies, and circular business models, the industry can move towards a more regenerative and environmentally conscious approach. Overcoming challenges will require collective efforts from stakeholders across the supply chain, along with consumer engagement and support. Through collaboration and innovative solutions, the footwear industry can pave the way for a more sustainable and circular future.

LECTURE 3
CIRCULAR ECONOMY TOOLS AND INSTRUMENTS: ECO LABEL, PRODUCT ENVIRONMENTAL FOOTPRINT, GREEN PUBLIC PROCUREMENT, RAW MATERIALS INITIATIVE, REACH, ECO-INNOVATION

3.1. ECO LABEL

Introduction to Eco Labels and their Role in Promoting Sustainable Consumption

Eco labels are valuable tools in the transition towards a circular economy, as they play a crucial role in promoting sustainable consumption. An eco label is a voluntary certification that provides consumers with information about the environmental performance of a product or service. It aims to empower consumers to make informed choices and encourages businesses to adopt more environmentally friendly practices.

The primary objective of eco labels is to highlight the ecological impact of products or services throughout their life cycle. This life-cycle perspective considers factors such as raw material extraction, production processes, transportation, use, and disposal. By providing clear and credible information, eco labels enable consumers to choose products that have a reduced environmental footprint.

Eco Label Certification Schemes and their Criteria

Various eco label certification schemes exist globally, each with its own criteria and focus areas. Some well-known schemes include the EU Ecolabel, ENERGY STAR, and the Blue Angel. The EU Ecolabel, for instance, evaluates products based on factors such as energy efficiency, resource use, and greenhouse gas emissions. ENERGY STAR focuses on energy efficiency, particularly for electronic devices and appliances, while the Blue Angel emphasizes low emissions and minimal use of hazardous substances.

Common criteria among eco label certification schemes include the use of sustainable raw materials, reduced energy consumption, minimal greenhouse gas emissions, waste reduction, and recyclability. The criteria often evolve over time to reflect advancements in sustainability practices and scientific knowledge.

Case Studies of Successful Eco Label Implementation in Various Sectors

Sustainable Textiles: The Global Organic Textile Standard (GOTS) has significantly impacted the textile industry. It ensures that textiles are produced using environmentally friendly processes, from the

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organic cultivation of raw materials to socially responsible manufacturing. GOTS-certified products are widely recognized and have gained traction among conscious consumers.

Energy-Efficient Appliances: ENERGY STAR has been a successful eco label in the electronics and appliance industry. By labeling energy-efficient products, consumers are encouraged to choose energy-saving alternatives, leading to reduced energy consumption and lower greenhouse gas emissions.

Green Building: The Leadership in Energy and Environmental Design (LEED) certification is widely adopted in the construction sector. It assesses the environmental performance of buildings, considering aspects like energy efficiency, water usage, sustainable materials, and indoor air quality. LEED-certified buildings are associated with lower energy consumption and a smaller carbon footprint.

In conclusion, eco labels are powerful tools that promote sustainable consumption by providing transparent information about the environmental impact of products and services. These labels empower consumers to make responsible choices and motivate businesses to adopt more sustainable practices. Through various eco label certification schemes, a wide range of sectors can contribute to the circular economy and work towards a greener and more sustainable future.

3.2. PRODUCT ENVIRONMENTAL FOOTPRINT

Product Environmental Footprint

The product environmental footprint is a comprehensive assessment of the environmental impact of a product throughout its life cycle. It goes beyond traditional eco-labeling by considering a broader range of environmental factors. This footprint takes into account various stages of a product's life, including raw material extraction, production, distribution, use, and end-of-life treatment. By quantifying environmental impacts, it provides a holistic view of a product's sustainability and helps consumers and businesses make informed decisions.

The concept of a product environmental footprint aligns perfectly with the circular economy's principles, as it aims to minimize negative environmental impacts while maximizing resource efficiency and sustainable practices.

Overview of the Methodology and Indicators Used for Assessing Environmental Impact

The assessment of a product's environmental footprint involves a well-defined methodology and various indicators. Life Cycle Assessment (LCA) is a widely used methodology for this purpose. It evaluates the environmental impact of a product at each life cycle stage and allows for the comparison of different products in terms of their environmental performance.

Some key indicators commonly used in assessing environmental impact include:

Carbon Footprint: Measures the greenhouse gas emissions associated with a product's life cycle, expressed in CO2 equivalent units. It helps identify the contribution to climate change.
Water Footprint: Quantifies the amount of freshwater consumed or polluted during a product's life cycle, considering both direct and indirect water use.
Land Use: Assesses the amount of land required for raw material extraction, production, and waste disposal.
Resource Depletion: Measures the consumption of non-renewable resources, such as fossil fuels and minerals.
Toxicity Potential: Evaluates the potential harm a product's substances may cause to human health or the environment.

Examples of How Product Environmental Footprint is Used in Decision-Making and Product Design

Sustainable Sourcing: Companies can use product environmental footprint data to identify environmentally harmful raw materials and prioritize the use of sustainable alternatives. By choosing materials with lower environmental impacts, businesses can reduce their products' overall ecological footprint.

Eco-Design: Designers can utilize environmental footprint assessments to identify areas for improvement in product design. By optimizing product design and manufacturing processes, they can create more eco-friendly products with reduced environmental impacts.
Consumer Awareness: Transparent environmental footprint information enables consumers to make informed choices. Eco-conscious consumers are more likely to choose products with lower environmental footprints, influencing manufacturers to produce greener alternatives.
Corporate Sustainability Strategies: Companies can set ambitious sustainability goals by analyzing the environmental footprints of their products. This information helps in developing strategies to reduce overall environmental impacts and aligns with corporate sustainability commitments.
Public Policy and Regulations: Governments and regulatory bodies can use product environmental footprint data to shape policies and regulations that incentivize sustainable practices and foster a circular economy.

In conclusion, the product environmental footprint provides a comprehensive assessment of a product's environmental impact throughout its life cycle. By using this data in decision-making, product design, and policymaking, businesses and consumers can contribute to a more sustainable and circular economy, reducing their ecological footprint and promoting environmental preservation.

3.3. GREEN PUBLIC PROCUREMENT

Introduction to Green Public Procurement and its Significance in Promoting Circular Economy Principles

Green Public Procurement (GPP) is a strategic approach where public authorities, such as governments and public institutions, integrate environmental considerations into their procurement processes. The goal of GPP is to promote sustainable consumption and production by favoring goods, services, and works with lower environmental impacts. By leveraging the purchasing power of the public sector, GPP plays a vital role in driving market demand for sustainable products and services, thus advancing circular economy principles.

GPP supports the transition towards a circular economy in several ways:

Stimulating Demand: By incorporating environmental criteria into procurement, GPP increases demand for environmentally friendly products and services. This, in turn, incentivizes businesses to innovate and adopt circular practices.

Eco-Design Encouragement: GPP encourages suppliers to develop products that meet strict environmental standards, fostering eco-design principles that prioritize durability, reparability, and recyclability.

Market Transformation: As public authorities opt for greener alternatives, it signals market demand for sustainable products, leading to a shift in the market towards circular and more sustainable practices.

Reduced Environmental Impact: GPP helps reduce the overall environmental impact of public sector activities by selecting products and services with lower carbon footprints and reduced resource consumption.

Criteria and Guidelines for Green Procurement

The criteria and guidelines for green procurement vary depending on the region and specific objectives of the procurement process. Generally, they encompass a range of environmental considerations throughout a product's life cycle, from extraction and production to use and end-of-life.

Some common criteria for green procurement include:

Environmental Certification: Products with recognized eco-labels or environmental certifications are favored in GPP. These certifications validate a product's adherence to specific environmental standards.

Energy Efficiency: GPP prioritizes products and services that consume less energy during their use phase, reducing overall energy consumption and greenhouse gas emissions.

Resource Efficiency: Products designed for durability, repairability, and recyclability are preferred, as they extend product lifespans and reduce waste generation.

Low Toxicity: GPP aims to minimize the use of hazardous substances in purchased products to protect human health and the environment.

Circular Business Models: Procurement processes may encourage suppliers to adopt circular business models, such as leasing, remanufacturing, or take-back schemes.

Case Studies Showcasing Successful Implementation of Green Public Procurement

The Netherlands: The Dutch government has successfully implemented GPP in various sectors, such as construction, transportation, and office supplies. By integrating sustainability criteria into their procurement policies, they have encouraged the adoption of energy-efficient buildings and sustainable transportation options.

City of Copenhagen, Denmark: Copenhagen has implemented GPP in public catering services, leading to the procurement of more sustainable and locally sourced food products. This initiative reduced the city's environmental footprint and supported local farmers and food producers.

European Union: The EU has adopted GPP as part of its sustainable development strategy. GPP criteria have been applied to various product groups, including computers, vehicles, and cleaning products, fostering market transformation towards greener and more circular alternatives.

In conclusion, Green Public Procurement is a powerful tool that leverages the influence of public authorities to promote sustainable consumption and production. By integrating environmental criteria into procurement processes, GPP encourages the adoption of circular economy principles, stimulates demand for sustainable products, and drives positive environmental and societal impacts. The successful implementation of GPP in various regions and sectors serves as a testament to its effectiveness in advancing sustainability goals.

3.4. RAW MATERIALS INITIATIVE

Overview of the European Union's Raw Materials Initiative

The European Union's Raw Materials Initiative (RMI) is a strategic framework aimed at ensuring a stable and sustainable supply of raw materials for the EU's industrial needs. Launched in 2008, the initiative recognizes the critical role raw materials play in the EU's economy and the need to address challenges related to their availability, access, and sustainable use. The RMI focuses on three key pillars:

Access to Raw Materials: The EU aims to secure a reliable and unhindered access to raw materials, both from domestic sources and through responsible trade with other countries.

Sustainable Supply of Raw Materials: The RMI promotes responsible and sustainable sourcing of raw materials, minimizing environmental and social impacts associated with their extraction and processing.

Resource Efficiency and Recycling: To reduce dependency on primary raw materials, the RMI encourages resource efficiency and the development of recycling technologies to recover valuable materials from products at the end of their life.

The Importance of Sustainable Sourcing and Efficient Use of Raw Materials

Sustainable sourcing and efficient use of raw materials are essential components of a circular economy and contribute to multiple benefits:

Environmental Conservation: Unsustainable extraction and use of raw materials can lead to deforestation, habitat destruction, and increased greenhouse gas emissions. Sustainable sourcing helps conserve ecosystems and reduces the environmental impact of raw material extraction.

Climate Change Mitigation: Extracting, processing, and transporting raw materials often consume significant amounts of energy and release greenhouse gases. By using raw materials more efficiently and transitioning to renewable resources, we can mitigate the impact of climate change.

Resource Conservation: Efficient use of raw materials extends their lifespan and reduces the demand for new resources. It minimizes waste generation and conserves valuable resources for future generations.

Social and Economic Benefits: Responsible raw material sourcing supports local communities by ensuring fair labor practices and reducing potential negative social impacts associated with mining or extraction activities.

Resilience and Security: Diversifying raw material sources and promoting recycling enhance the EU's resilience to supply disruptions and reduce dependency on non-renewable resources from politically unstable regions.

Examples of Initiatives Promoting Responsible Raw Material Extraction and Use

Conflict Minerals Regulation: The EU has implemented regulations to address the issue of conflict minerals, such as tin, tantalum, tungsten, and gold, which often finance armed conflicts and human rights abuses. The regulation requires companies to conduct due diligence and ensure responsible sourcing practices throughout their supply chains.

EIT RawMaterials: The European Institute of Innovation and Technology (EIT) runs the RawMaterials Community, which brings together industry, academia, and research institutions to promote innovation and sustainable practices in the raw materials sector.

Circular Economy Action Plan: The EU's Circular Economy Action Plan outlines measures to promote sustainable resource management and waste prevention. It encourages the design of products for circularity and supports the use of secondary raw materials in manufacturing processes.

Urban Mining: Initiatives focusing on urban mining promote the recovery of valuable materials from end-of-life products and waste streams within cities. This reduces the demand for primary raw materials and contributes to a more circular economy.

In conclusion, the European Union's Raw Materials Initiative aims to ensure a stable and sustainable supply of raw materials, emphasizing responsible sourcing and resource efficiency. By promoting sustainable practices and initiatives, the EU strives to reduce the environmental and social impacts of raw material extraction and use, supporting the transition towards a circular economy and a more sustainable future.

3.5. REACH (REGISTRATION, EVALUATION, AUTHORIZATION, AND RESTRICTION OF CHEMICALS)

Introduction to the REACH Regulation and its Objectives

REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) is a comprehensive regulation adopted by the European Union (EU) in 2007 to ensure the safe use of chemicals and protect human health and the environment. Its primary objectives are to improve the understanding of chemicals' properties, assess their risks, and promote the use of safer alternatives when necessary. The key objectives of REACH are as follows:

Registration: Manufacturers and importers must register all substances produced or imported into the EU in quantities exceeding one ton per year. This registration process gathers essential data on the properties and hazards of chemicals, enabling better chemical management and safety.

Evaluation: Competent authorities evaluate the registration dossiers to ensure compliance with REACH requirements. They may request further information or take regulatory actions if concerns about the substance's risks arise.

Authorization: Substances of very high concern (SVHC), such as carcinogens, mutagens, and reproductive toxins, may require authorization to be used in the EU market. Authorization aims to ensure that SVHCs are progressively replaced with safer alternatives.

Restriction: REACH allows the restriction or prohibition of certain hazardous substances, mixtures, or articles when their risks cannot be adequately controlled. This process ensures high levels of protection for human health and the environment.

Explanation of the Registration, Evaluation, Authorization, and Restriction Processes

Registration: Manufacturers and importers of substances must submit a registration dossier to the European Chemicals Agency (ECHA). The dossier includes data on the substance's properties, uses, and safe handling instructions. Companies must also demonstrate how they manage the risks associated with the substance.

Evaluation: ECHA and the EU Member States evaluate the submitted registration dossiers to assess their compliance with the requirements. This evaluation can lead to additional information requests or the initiation of risk management measures, such as substance-specific restrictions.

Authorization: Substances identified as SVHCs and listed on the Candidate List may require authorization for their use. Companies seeking authorization must demonstrate that the risks associated with the substance are adequately controlled, or that the socio-economic benefits of its use outweigh the risks, and that no suitable alternatives exist.

Restriction: REACH enables the restriction of substances, mixtures, or articles when their use poses unacceptable risks to human health or the environment. The restriction process involves a thorough risk assessment and a socio-economic analysis.

Case Studies Highlighting the Impact of REACH on Chemical Safety and Sustainable Practices

Phthalates Restrictions: REACH has imposed restrictions on certain phthalates used in various consumer products due to their adverse effects on human health and the environment. The restriction led to the development of safer alternatives in products such as toys, cosmetics, and medical devices.

Substitution of Hazardous Substances: The authorization process has encouraged companies to seek alternatives for SVHCs, leading to the development and use of safer chemicals and products. For example, some SVHC flame retardants in electronics have been replaced with more environmentally friendly options.

Improved Chemical Data Availability: The registration process under REACH has significantly increased the availability of chemical data and information. This enhanced knowledge has empowered industries, regulators, and consumers to make more informed decisions about chemical safety and sustainability.

Enhanced Collaboration: REACH has encouraged collaboration among industries, research institutions, and regulatory bodies to address chemical safety concerns and develop innovative and safer alternatives.

In conclusion, the REACH regulation plays a crucial role in promoting chemical safety, sustainable practices, and the responsible use of chemicals within the European Union. Through its registration, evaluation, authorization, and restriction processes, REACH has led to the substitution of hazardous substances with safer alternatives, increased chemical data transparency, and improved the overall protection of human health and the environment.

3.6. ECO-INNOVATION

Definition and Importance of Eco-Innovation in the Circular Economy Context

Eco-innovation refers to the development and adoption of new products, processes, or services that result in significant environmental benefits. In the context of the circular economy, eco-innovation plays a pivotal role in finding sustainable solutions that promote resource efficiency, reduce waste, and minimize the environmental impact of economic activities.

The importance of eco-innovation in the circular economy context lies in its ability to address pressing environmental challenges while driving economic growth. By fostering creativity and promoting the integration of environmental considerations into innovation, eco-innovation encourages businesses to transition from a linear "take, make, dispose" model to a more sustainable circular approach. This shift not only reduces the consumption of finite resources but also stimulates job creation and drives competitiveness in the market.

Overview of Eco-Innovative Solutions and Technologies

Circular Design and Materials: Eco-innovative solutions focus on designing products and materials for durability, reparability, and recyclability. This approach ensures that products have extended lifespans and can be easily disassembled and repurposed at the end of their use.

Renewable Energy Technologies: Eco-innovation drives the development and implementation of renewable energy sources, such as solar, wind, and geothermal energy. These technologies help decarbonize energy production, reducing greenhouse gas emissions and mitigating climate change impacts.

Waste Reduction and Recycling: Eco-innovation leads to advancements in waste management practices, including improved recycling technologies and processes for various materials. These solutions contribute to the recovery of valuable resources from waste streams and reduce the burden on landfills.

Resource-Efficient Manufacturing: Eco-innovative technologies optimize manufacturing processes to minimize raw material consumption, energy use, and waste generation. Techniques like 3D printing and lean manufacturing promote resource efficiency and sustainability.

Smart and Sustainable Transportation: Eco-innovation supports the development of sustainable transportation solutions, such as electric vehicles, alternative fuels, and smart mobility systems, to reduce the environmental impact of the transportation sector.

Examples of Successful Eco-Innovation Initiatives in Different Industries

Fashion Industry: Eco-innovation initiatives in the fashion industry involve the use of sustainable and bio-based materials, such as recycled polyester and plant-based fibers like

Tencel. Additionally, circular design principles are employed to create clothing that can be easily disassembled and recycled.

Food and Agriculture: Eco-innovations in the food industry include sustainable packaging solutions, reduced food waste strategies, and the development of alternative proteins, such as plant-based and lab-grown meats.

Construction and Buildings: The construction industry adopts eco-innovative practices by using green building materials, incorporating energy-efficient technologies, and designing buildings for optimal energy and resource use.

Electronics: Eco-innovation in the electronics industry involves developing products with longer lifespans, modular components for easier repairs, and environmentally friendly materials free of hazardous substances.

Renewable Energy: The ongoing development and deployment of renewable energy technologies, such as solar panels and wind turbines, showcase successful eco-innovation initiatives contributing to the transition to cleaner energy sources.

In conclusion, eco-innovation is a critical driver in the circular economy, promoting sustainable practices and providing solutions to environmental challenges. By fostering the development and adoption of eco-innovative solutions and technologies, industries can transition towards more resource-efficient and environmentally friendly practices, ultimately contributing to a greener and more sustainable future.

3.7. IMPLEMENTING CIRCULAR ECONOMY TOOLS: CHALLENGES AND BEST PRACTICES

Identification of Common Challenges in Implementing Circular Economy Tools

Lack of Awareness and Understanding: One of the primary challenges in implementing circular economy tools is the lack of awareness and understanding among stakeholders, including businesses, consumers, and policymakers. Without a clear understanding of circular economy principles and tools, it becomes challenging to garner support and participation.

Regulatory Barriers: Existing regulations and policies may not always align with circular economy practices, creating barriers for the adoption of circular economy tools. This can include issues with waste management regulations, product standards, and financial incentives that favor linear models.

Economic Viability: Transitioning to circular practices often requires upfront investments in technology, infrastructure, and process redesign. Some businesses may be hesitant to invest in circular economy solutions if they perceive them as economically risky or unprofitable in the short term.

Supply Chain Complexities: Implementing circular economy tools may involve changes in supply chain management and collaboration with multiple stakeholders. Complex supply chains can pose challenges in terms of information sharing, traceability, and cooperation.

Consumer Behavior: Circular economy models often rely on consumer willingness to adopt more sustainable consumption patterns, such as repair, reuse, and sharing. Encouraging behavior change and creating demand for circular products and services can be difficult.

Strategies to Overcome Challenges

Education and Awareness: Raising awareness about the benefits and potential of circular economy tools is crucial. Governments, businesses, and NGOs can collaborate to conduct educational campaigns and workshops to inform stakeholders about circular economy principles and the positive impact of its tools.

Policy Support: Policymakers can play a key role in overcoming regulatory barriers by developing and enforcing supportive policies. This may include tax incentives for circular practices, extended producer responsibility schemes, and stricter environmental regulations.

Financial Support and Incentives: Governments and financial institutions can provide financial support and incentives to businesses for adopting circular economy practices. This can include grants, low-interest loans, and subsidies to promote circular investments.

Collaboration and Partnerships: Addressing supply chain complexities requires collaboration and partnerships among different stakeholders. Governments can facilitate these partnerships and encourage information sharing to enhance supply chain transparency.

Behavior Change Campaigns: Encouraging sustainable consumer behavior can be achieved through targeted behavior change campaigns, highlighting the benefits of circular products, and promoting responsible consumption habits.

Sharing Best Practices and Success Stories from Different Sectors

Patagonia's Worn Wear Program: Patagonia, a renowned outdoor clothing brand, launched its Worn Wear program to promote circular practices. The program encourages customers to buy, sell, and trade used Patagonia garments, extending their lifespan and reducing overall environmental impact.

Ellen MacArthur Foundation's Circular Economy 100 Network: The Circular Economy 100 (CE100) network brings together leading businesses, governments, and cities to share knowledge and collaborate on circular economy initiatives. The network enables best practice sharing and fosters innovation across sectors.

Philips' Circular Economy Initiatives: Philips, a global technology company, has embraced circular economy principles in its lighting and healthcare businesses. Through the "Pay-Per-Lux" model, Philips provides lighting solutions as a service, encouraging energy-efficient products and maintenance services.

BMW's Circular Economy Approach: BMW has implemented a closed-loop approach to manufacturing, with a focus on recycling and remanufacturing of components and materials in their production processes. This approach reduces waste and conserves resources.

The City of Amsterdam's Circular Economy Strategy: Amsterdam has adopted a comprehensive circular economy strategy, which includes measures to promote circular construction, circular procurement, and waste reduction. The city actively engages citizens and businesses in circular practices.

In conclusion, implementing circular economy tools faces various challenges, including awareness gaps, regulatory barriers, economic considerations, supply chain complexities, and consumer behavior. However, strategies such as education, policy support, financial incentives, collaboration, and behavior change campaigns can help overcome these challenges. Sharing best practices and success stories from different sectors demonstrates the feasibility and benefits of adopting circular economy practices, inspiring others to follow suit and contribute to a more sustainable future.

3.8. FUTURE PERSPECTIVES AND EMERGING TRENDS

Overview of Emerging Trends and Developments in Circular Economy for Footwear

Design for Disassembly: Emerging trends in footwear design focus on creating products that are easy to disassemble and repair. Shoes are being designed with modular components, making it easier to replace worn-out parts and extend the product's lifespan.

Sustainable Materials: Footwear manufacturers are exploring sustainable materials, such as bio-based polymers, recycled textiles, and plant-based leather alternatives. These materials reduce the reliance on non-renewable resources and lower the environmental impact of footwear production.

Product-as-a-Service (PaaS) Models: PaaS models are being explored in the footwear industry, allowing consumers to lease or subscribe to shoes instead of purchasing them outright. This approach encourages manufacturers to produce durable and long-lasting footwear.

Circular Design and Material Traceability: Circular design principles are being applied to footwear, focusing on minimizing waste and ensuring materials are traceable throughout the product's life cycle. Technologies like blockchain enable transparent supply chains and material provenance.

3D Printing and Customization: 3D printing is revolutionizing footwear manufacturing by enabling on-demand production and customization. This reduces waste by producing shoes based on specific customer needs and foot measurements.

Potential Impact of Technological Advancements and Policy Changes

Advanced Recycling Technologies: Advancements in recycling technologies, such as chemical recycling and material separation methods, can help close the loop in footwear production by converting end-of-life shoes into high-quality materials for new shoes.

Extended Producer Responsibility (EPR): Policy changes that mandate footwear manufacturers to take responsibility for the entire product life cycle can drive circularity. EPR schemes encourage design for durability and recyclability, incentivizing manufacturers to adopt circular practices.

Circular Material Standards: Developing and implementing circular material standards can promote the use of sustainable and recyclable materials in footwear production. Such standards can drive market demand for circular materials and encourage innovation in material development.

Digital Platforms for Circular Footwear: Digital platforms that facilitate shoe sharing, swapping, and reselling can extend the lifespan of shoes and reduce overall consumption. Policy support for these platforms can encourage consumer participation and foster circular business models.

Highlighting the Importance of Continuous Learning and Adaptation in a Dynamic Field

In the context of applying circular economy principles to footwear design and manufacture, continuous learning and adaptation are essential. Footwear designers and manufacturers should:

Stay Informed: Keep abreast of the latest circular economy trends, materials, and technologies to integrate sustainable practices into footwear design and manufacturing.

Collaborate with Partners: Engage with suppliers, industry stakeholders, and circular economy experts to share knowledge, best practices, and challenges in the circular footwear ecosystem.

Embrace Circular Design Thinking: Adopt circular design principles and methodologies to create footwear products that minimize waste, are easy to repair, and have longer lifespans.

Leverage Digital Tools: Utilize digital tools and data analytics to optimize supply chain management, material traceability, and consumer engagement in circular footwear initiatives.

Advocate for Policy Support: Collaborate with policymakers to advocate for supportive regulations, incentives, and extended producer responsibility schemes that promote circular practices in the footwear industry.

In conclusion, the future of applying circular economy principles in the design and manufacture of footwear holds significant promise. Through sustainable materials, circular design, advanced recycling technologies, and policy support, the footwear industry can transition towards a more resource-efficient and environmentally friendly approach. Continuous learning and adaptation in this dynamic field will be crucial to drive positive change and contribute to a circular and sustainable future for the footwear industry.

LECTURE 4
APPLICATION OF LIFE CYCLE ANALYSIS IN FOOTWEAR DESIGN: ENHANCING SUSTAINABILITY AND ENVIRONMENTAL PERFORMANCE

4.1. ECO LABEL

Definition and Significance of Life Cycle Analysis (LCA) in the Context of Footwear Design

Life Cycle Analysis (LCA) is a systematic and comprehensive method used to evaluate the environmental impacts of a product throughout its entire life cycle, from raw material extraction to end-of-life disposal. In the context of footwear design, LCA provides a holistic approach to assess the environmental footprint of shoes, allowing designers and manufacturers to make informed decisions and improve the sustainability of their products.

The purpose of LCA is to identify, quantify, and evaluate the potential environmental impacts associated with each stage of the footwear life cycle. These impacts may include greenhouse gas emissions, energy consumption, water usage, material depletion, and waste generation. By conducting an LCA, designers can understand the cradle-to-grave environmental consequences of different design choices and materials, enabling them to optimize shoe design for greater eco-efficiency.

Overview of the Different Stages of the Footwear Life Cycle

The footwear life cycle typically comprises several stages:

Raw Material Extraction: This stage involves the extraction of raw materials like leather, rubber, synthetic materials, and various chemicals used in shoe manufacturing.

Shoe Manufacturing: During this stage, the raw materials are processed and assembled into footwear, including cutting, stitching, molding, and gluing processes.

Distribution and Retail: This stage involves transportation and storage of the shoes to distribution centers and retail outlets.

Use Phase: The shoes are worn and used by consumers during this stage, which includes cleaning and maintenance activities.

End-of-Life Treatment: At the end of their life, shoes may be discarded, donated, recycled, or end up in landfills.

Benefits and Importance of Applying LCA in Footwear Design

The application of LCA in footwear design offers several benefits and is of significant importance in promoting sustainability:

Environmental Impact Assessment: LCA enables a detailed evaluation of the environmental impact of footwear, helping designers identify "hotspots" where the highest environmental impacts occur, such as in material production or shoe disposal.

Eco-Design Optimization: By analyzing the environmental impact of different design choices and materials, designers can optimize shoe designs for reduced environmental burden, aiming for more eco-friendly products.

Informed Decision-Making: LCA provides designers and manufacturers with reliable data and information to make informed decisions on material selection, manufacturing processes, and product improvements.

Resource Efficiency: LCA facilitates resource-efficient design, encouraging the use of sustainable and renewable materials, as well as efficient production and distribution methods.

Environmental Labels and Marketing: LCA results can be used to support eco-labeling and green marketing efforts, showcasing a brand's commitment to sustainability and helping consumers make more informed choices.

In conclusion, Life Cycle Analysis (LCA) is a valuable tool in footwear design as it assesses the environmental impacts associated with the entire life cycle of shoes. By providing designers and manufacturers with detailed environmental data, LCA enables eco-efficient decision-making, resource optimization, and the development of more sustainable footwear. Embracing LCA in the footwear industry is crucial for achieving environmental goals and promoting sustainable practices in the design and production of shoes.

4.2. LIFE CYCLE ASSESSMENT METHODOLOGY

Introduction to the Methodology of Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is a standardized and scientific methodology used to evaluate the environmental impacts of a product, process, or service over its entire life cycle. LCA provides a comprehensive approach to assess the environmental burdens and potential hotspots associated with each stage, from raw material extraction to end-of-life disposal. It follows a structured framework, allowing for systematic data collection, analysis, and interpretation to make informed decisions on sustainability improvements.

The primary goal of LCA is to quantify the environmental impacts of a product holistically, taking into account not only the direct impacts of manufacturing but also indirect effects related to material production, transportation, use, and disposal. LCA results provide valuable insights to support eco-design, resource efficiency, and sustainable decision-making.

Explanation of the Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) Phases

Life Cycle Inventory (LCI) Phase:

The LCI phase involves the compilation and quantification of all inputs (materials, energy, and water) and outputs (emissions, waste, and co-products) associated with each stage of the product's life cycle. This data is collected in a structured manner to create a life cycle inventory database. The LCI provides a detailed picture of the resource consumption and environmental emissions at each stage.

Life Cycle Impact Assessment (LCIA) Phase:

In the LCIA phase, the inventory data is evaluated to assess the potential environmental impacts based on specific impact categories. These impact categories represent various environmental concerns, such as climate change, ozone depletion, acidification, eutrophication, and resource depletion. During LCIA, mathematical models and characterization factors are used to quantify the impacts and express them in common units, such as kilograms of CO_2 equivalent for climate change.

Key Indicators and Environmental Impact Categories Considered in Footwear LCA

Footwear LCA considers a range of key indicators and environmental impact categories that are relevant to its life cycle stages. Some key indicators include:

Global Warming Potential (GWP): Measures the total greenhouse gas emissions, primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), associated with the footwear life cycle. It quantifies the product's contribution to global warming and climate change.

Energy Footprint: Evaluates the total energy consumption during the footwear life cycle, including direct and indirect energy inputs, such as electricity, fuel, and heat.

Water Footprint: Assesses the total water consumption and potential impacts on water resources, including freshwater withdrawal and wastewater discharges during the life cycle.

Resource Depletion: Measures the depletion of non-renewable resources, such as fossil fuels and minerals, due to material extraction and processing for footwear production.

Abiotic Depletion Potential: Quantifies the potential for depleting non-living resources, such as minerals and metals, due to footwear manufacturing.

Eutrophication: Assesses the potential for nutrient enrichment in water bodies, leading to excessive growth of algae and adverse impacts on aquatic ecosystems.

Acidification: Measures the potential to release acidic compounds into the atmosphere, contributing to acid rain and ecosystem damage.

Ozone Depletion Potential: Assesses the potential impact on the ozone layer due to the release of ozone-depleting substances during the footwear life cycle.

By considering these key indicators and environmental impact categories, footwear LCA provides a comprehensive understanding of the product's environmental performance and supports the development of more sustainable and eco-friendly footwear designs and production processes.

In conclusion, Life Cycle Assessment (LCA) is a valuable methodology in evaluating the environmental impacts of footwear over its entire life cycle. The LCI and LCIA phases enable the systematic analysis of inputs, outputs, and potential impacts, while key indicators and impact categories provide insights into the product's environmental performance. By adopting LCA in footwear design and manufacturing, stakeholders can make informed decisions to minimize the environmental footprint of footwear and contribute to a more sustainable footwear industry.

4.3. DATA COLLECTION AND INVENTORY ANALYSIS

Strategies for Data Collection and Establishing a Comprehensive Footwear LCI

A. Strategies for Data Collection:

Data collection is a crucial step in establishing a comprehensive footwear Life Cycle Inventory (LCI). Strategies for data collection in footwear LCA include:

Primary Data Collection: Gathering data directly from footwear manufacturers, suppliers, and retailers through surveys, interviews, and on-site visits. This approach ensures accuracy and relevance of the data specific to the footwear being assessed.

Secondary Data Sources: Utilizing existing databases, industry reports, and scientific literature for commonly used materials, processes, and transportation data. These databases can provide generic data that can be adapted and adjusted to fit the specific footwear being analyzed.

Collaboration and Partnerships: Engaging in partnerships with industry associations, research institutions, and governmental organizations can facilitate data sharing and access to industry-specific data.

Standardized Protocols: Following standardized protocols and guidelines, such as ISO 14040 and ISO 14044, ensures consistency and comparability of LCA results across different footwear products.

Identification and Quantification of Inputs, Outputs, and Emissions throughout the Footwear Life Cycle

The footwear LCI involves identifying and quantifying inputs (materials, energy, and water), outputs (products, co-products, and waste), and emissions (greenhouse gases, pollutants) throughout the footwear life cycle. Key stages and considerations include:

Raw Material Extraction: Identifying the raw materials used in footwear production, their sources, and environmental impacts associated with their extraction and processing.

Manufacturing: Quantifying energy consumption, water usage, and emissions during shoe manufacturing, including production waste and process-related emissions.

Transportation: Assessing the environmental impacts of transporting materials and finished shoes throughout the supply chain, considering distance, mode of transport, and fuel types.

Use Phase: Evaluating energy consumption during shoe use, including cleaning and maintenance activities, and potential impacts from user behavior.

End-of-Life: Analyzing the environmental consequences of footwear disposal, whether through recycling, landfilling, or incineration.

Case Studies Illustrating Data Collection Challenges and Best Practices in Footwear LCA

CASE STUDY 1: Data Collection Challenges in Footwear LCA

Challenge: Limited Access to Supplier Data

In a footwear LCA, a company faced challenges in obtaining comprehensive data from its suppliers due to reluctance to share sensitive information, proprietary concerns, or lack of resources for data collection.

Best Practice: Collaboration and Supplier Engagement

The company adopted a collaborative approach by forming partnerships with suppliers and establishing a sustainability network. They educated suppliers on the benefits of LCA and offered support in data collection, leading to improved data availability and transparency.

CASE STUDY 2: Best Practices in Footwear LCA

Challenge: Identifying Environmental Hotspots

A footwear manufacturer sought to identify the main environmental hotspots in their product's life cycle to prioritize sustainability improvements effectively.

Best Practice: Hotspot Analysis and Eco-Design Strategies

The manufacturer conducted a hotspot analysis, focusing on areas with the highest impacts. They employed eco-design strategies, such as material substitution and process optimization, resulting in a reduced environmental footprint for their footwear.

CASE STUDY 3: Integration of Technology in Footwear LCA

Challenge: Resource-Intensive Data Collection

A shoe company faced resource-intensive and time-consuming data collection processes during LCA.

Best Practice: Technology Integration

The company integrated digital tools and data management systems to streamline data collection. They used sensors, RFID tags, and automated data collection, significantly reducing the time and resources required for LCI development.

In conclusion, data collection and inventory analysis are essential steps in conducting a comprehensive footwear Life Cycle Assessment (LCA). Strategies such as primary data collection, secondary data sources, collaboration, and adherence to standardized protocols enable the establishment of a robust LCI. Identification and quantification of inputs, outputs, and emissions throughout the footwear life cycle provide valuable insights to drive sustainability improvements.

Case studies showcase data collection challenges and best practices, emphasizing the significance of supplier engagement, technology integration, and hotspot analysis in achieving meaningful results in footwear LCA.

4.4. IMPACT ASSESSMENT AND INTERPRETATION

Evaluation of Environmental Impacts Using Impact Assessment Methods

A. Evaluation of Environmental Impacts:

The impact assessment phase of Life Cycle Assessment (LCA) evaluates the data collected in the Life Cycle Inventory (LCI) and quantifies the environmental impacts of the footwear throughout its life cycle. Impact assessment methods translate the inventory data into environmental indicators representing specific impact categories, such as climate change, resource depletion, acidification, eutrophication, and human toxicity.

Interpretation of LCA Results and Identification of Hotspots in the Footwear Life Cycle

B. Interpretation of LCA Results:

Interpreting LCA results involves analyzing the environmental indicators to understand the significance of each impact category. It helps identify areas of the footwear life cycle that contribute most to the overall environmental impacts. The interpretation phase allows designers, manufacturers, and stakeholders to prioritize improvement opportunities and make informed decisions for sustainability enhancements.

C. Identification of Hotspots in the Footwear Life Cycle:

Hotspots are stages or processes in the footwear life cycle with a disproportionate environmental impact. Through interpretation, LCA practitioners identify these hotspots, which can be specific materials, manufacturing processes, transportation, or disposal methods. Addressing hotspots is essential for focusing improvement efforts and achieving meaningful sustainability gains.

Limitations and Uncertainties in LCA Interpretation:

Data Quality and Availability: LCA heavily relies on data availability and quality. Data gaps, inaccuracies, or reliance on secondary data sources can introduce uncertainties in the results and impact assessment.

Allocation Methods: In cases where multiple products are co-produced, allocation methods are used to assign environmental burdens to each product. The choice of allocation method can affect the results and may lead to divergent interpretations.

Scope and System Boundaries: Decisions regarding the scope and system boundaries of the LCA can impact the results. Choosing which life cycle stages to include or exclude may alter the overall environmental impact assessment.

Spatial and Temporal Variability: Environmental impacts can vary geographically and over time. Applying regional-specific data and accounting for temporal variability can improve the accuracy of LCA results.

Simplifications and Assumptions: LCA models often involve simplifications and assumptions to manage complexity. These assumptions may introduce uncertainties that affect the interpretation of results.

Indirect Effects and Rebound Effects: Indirect effects, such as shifts in demand or rebound effects, can occur when eco-efficient improvements lead to increased consumption or production in other areas. These complexities can be challenging to capture in LCA interpretation.

Addressing Limitations and Uncertainties:

Sensitivity Analysis: Performing sensitivity analyses to assess the impact of varying key parameters can enhance the robustness of LCA results and interpretation.

Transparency and Disclosure: Transparently reporting the data, methods, and assumptions used in LCA facilitates peer review and enables stakeholders to understand the uncertainties associated with the interpretation.

Continuous Improvement: Acknowledging the limitations of LCA interpretation encourages continuous improvement in data collection methods, modeling techniques, and impact assessment methodologies.

In conclusion, impact assessment and interpretation are crucial steps in Life Cycle Assessment (LCA) to evaluate the environmental impacts of footwear. Through the identification of hotspots and understanding the limitations and uncertainties, LCA provides valuable insights to guide sustainability improvements in footwear design and production. Addressing data quality, allocation methods, system boundaries, and considering temporal and spatial variability can enhance the accuracy and reliability of LCA results and interpretations. Emphasizing transparency, sensitivity analysis, and continuous improvement ensures that LCA remains a robust tool for informed decision-making in the pursuit of sustainable footwear practices.

4.5. FOOTWEAR DESIGN STRATEGIES FOR ENVIRONMENTAL IMPROVEMENT

Design for Sustainability Principles and Strategies

A. Design for Sustainability Principles:

Design for Sustainability is an approach that aims to create footwear products with reduced environmental impact throughout their life cycle. Key principles include:

Material Selection: Opting for sustainable and eco-friendly materials, such as organic or recycled fibers, bio-based polymers, and chrome-free leathers, reduces the environmental footprint of footwear.

Durability and Longevity: Designing shoes for durability and extended lifespan encourages consumers to keep and use them for a longer time, reducing the need for frequent replacements.

Minimal Waste: Minimizing material waste during the design and manufacturing process reduces resource consumption and lowers the environmental impact of footwear production.

Repairability and Upgradability: Incorporating features that allow for easy repairs and upgrades extends the useful life of footwear, promoting a circular approach to product use.

Lightweight Design: Lightweight footwear reduces energy consumption during transportation and use, contributing to lower carbon emissions.

Eco-Efficient Packaging: Using eco-friendly and minimal packaging materials reduces waste and lowers the environmental impact of footwear distribution.

Integration of LCA Findings into the Footwear Design Process

The incorporation of LCA findings into the footwear design process can be achieved through the following steps:

LCA Data Utilization: Designers analyze the LCA results to identify hotspots and understand the environmental impacts of different design options and material choices.

Eco-Design Workshops: Engaging designers in eco-design workshops fosters sustainability thinking and facilitates creative ideation for eco-friendly solutions.

Design Toolkits: Providing designers with toolkits that integrate LCA findings and sustainability criteria helps guide decision-making during the design process.

Collaborative Approach: Collaboration between designers, material specialists, and LCA experts ensures that sustainable considerations are embedded into the design from the outset.

Life Cycle Thinking: Encouraging life cycle thinking in design discussions helps designers consider the entire footwear life cycle and potential environmental impacts.

Case Studies Highlighting Successful Application of LCA-Driven Design Improvements

CASE STUDY 1: Sustainable Material Selection

Challenge: A footwear company aimed to reduce its environmental impact by improving material choices.

Solution: After conducting an LCA, the company identified that replacing conventional leather with plant-based leather alternatives significantly reduced its environmental footprint. They successfully introduced eco-friendly materials like Piñatex (made from pineapple fibers) and mushroom leather in their footwear design, enhancing the sustainability of their products.

CASE STUDY 2: Design for Disassembly

Challenge: A shoemaker sought to design shoes with a circular economy approach, aiming to increase recyclability and minimize waste.

Solution: LCA findings revealed that disassembly was a critical stage in the end-of-life phase. The company redesigned shoes with modular components, enabling easy disassembly for material recovery and recycling. This resulted in increased circularity and reduced waste generation.

CASE STUDY 3: Eco-Efficient Packaging

Challenge: A footwear brand wanted to improve the sustainability of its packaging.

Solution: LCA findings indicated that reducing packaging size and using recycled and recyclable materials would significantly lower environmental impacts. The company successfully implemented eco-efficient packaging, reducing its carbon footprint and waste generation.

In conclusion, employing Design for Sustainability principles and integrating LCA findings into the footwear design process is essential for environmental improvement. Designing footwear with sustainable materials, durability, minimal waste, and circularity in mind can significantly reduce its environmental impact. By using LCA as a guiding tool, footwear companies can make informed decisions and prioritize design improvements to achieve their sustainability goals successfully. The case studies demonstrate that LCA-driven design improvements can lead to innovative and eco-friendly footwear solutions, benefiting both the environment and consumers.

4.6. MATERIAL SELECTION AND FOOTPRINT REDUCTION

Importance of Sustainable Material Choices in Reducing Environmental Footprints

Sustainable material choices play a crucial role in reducing the environmental footprints of footwear. The materials used in footwear production significantly impact resource consumption, energy use, greenhouse gas emissions, and waste generation. By selecting sustainable materials, footwear designers and manufacturers can make a substantial positive impact on the environment.

Resource Conservation: Sustainable materials, such as recycled or renewable resources, contribute to resource conservation, reducing the need for virgin raw materials and minimizing environmental degradation.

Lower Carbon Footprint: Many conventional materials used in footwear have a high carbon footprint due to energy-intensive extraction and manufacturing processes. Sustainable materials often have lower emissions, contributing to climate change mitigation.

Reduced Waste Generation: Eco-friendly materials may be recyclable or biodegradable, reducing the amount of waste generated during footwear production and disposal.

Safer Chemical Use: Sustainable materials often involve fewer toxic chemicals, promoting worker and consumer safety while reducing environmental pollution.

Consumer Preference: With growing awareness of environmental issues, consumers are increasingly demanding sustainable products. Sustainable material choices can attract environmentally conscious consumers and enhance brand reputation.

Assessment of Material Impacts Through LCA

Life Cycle Assessment (LCA) is a valuable tool for assessing the environmental impacts of different materials used in footwear design. LCA enables a systematic evaluation of the entire life cycle of each material, including extraction, processing, manufacturing, distribution, use, and end-of-life treatment.

Cradle-to-Gate Analysis: LCA evaluates the environmental impacts of materials from their extraction (cradle) to the point of entry into the footwear manufacturing process (gate).

Comparative Analysis: LCA allows for the comparison of different materials, highlighting the environmental benefits and drawbacks of each option.

Identifying Hotspots: LCA helps identify stages in the material's life cycle with the most significant environmental impacts, guiding material selection for improved sustainability.

Sensitivity Analysis: LCA can be used to assess the impact of varying assumptions and parameters in material selection, improving the accuracy of decision-making.

Strategies for Material Substitution and Eco-Friendly Material Selection in Footwear Design

To reduce the environmental footprint of footwear, designers can adopt the following strategies:

Recycled Materials: Integrate recycled materials, such as recycled PET bottles or post-consumer textile waste, into footwear design. This reduces the demand for virgin materials and contributes to a circular economy approach.

Bio-based Materials: Utilize bio-based materials derived from renewable resources, such as plant-based fibers or biopolymers, to replace conventional petroleum-based materials.

Leather Alternatives: Explore sustainable leather alternatives like mushroom leather, apple leather, or Piñatex (pineapple leaf fiber), which offer eco-friendly alternatives to traditional leather.

Eco-friendly Dyes and Finishes: Choose eco-friendly dyes and finishes that reduce the use of harmful chemicals and minimize water pollution.

Design for Material Efficiency: Optimize material use through efficient pattern cutting and design, reducing waste during manufacturing.

Material Traceability: Prioritize materials with transparent supply chains and traceability to ensure ethical sourcing and minimize environmental impacts.

Collaborate with Suppliers: Collaborate with material suppliers to explore and develop new sustainable materials tailored to footwear requirements.

In conclusion, selecting sustainable materials is instrumental in reducing the environmental footprints of footwear. Through the use of Life Cycle Assessment (LCA), designers can assess the impacts of various materials and identify eco-friendly alternatives. Strategies for material substitution and eco-friendly material selection enable the footwear industry to make significant strides toward sustainability, contributing to a more responsible and environmentally friendly future. By integrating sustainable material choices into their designs, footwear designers and manufacturers can lead the way in fostering a more sustainable and ethical fashion industry.

4.7. MANUFACTURING AND PROCESS OPTIMIZATION

Evaluation of Manufacturing Processes and Their Environmental Impacts

The evaluation of manufacturing processes in the footwear industry is a fundamental step in understanding the environmental implications of footwear production. Footwear manufacturing involves a series of interconnected stages, each contributing to the overall environmental footprint of the product. By assessing these processes, companies can identify areas of high environmental impact and develop strategies for sustainability improvements.

One of the key considerations in evaluating manufacturing processes is the consumption of natural resources. From raw material extraction to finished product assembly, each step involves resource-intensive activities that contribute to greenhouse gas emissions, energy consumption, and water usage. For example, the extraction of raw materials like leather, rubber, and synthetic materials requires significant energy and water resources, while various chemical processes during manufacturing can result in emissions of hazardous pollutants.

Another aspect of evaluation involves waste generation and disposal. The footwear manufacturing process generates waste in the form of off-cuts, trimmings, and defective products. The improper management of waste can lead to environmental pollution and add to the overall environmental burden of the industry.

Moreover, transportation and logistics play a role in the environmental impact of manufacturing processes. The movement of materials and finished products over long distances can result in additional emissions and energy consumption.

To comprehensively assess the environmental impacts of manufacturing processes, companies often utilize Life Cycle Assessment (LCA) methodologies. LCA enables the quantification of the entire life cycle of footwear production, providing insights into the most significant environmental hotspots. By identifying these hotspots, manufacturers can target specific areas for improvement, leading to more sustainable practices and reduced environmental footprints.

In conclusion, the evaluation of manufacturing processes is a crucial aspect of understanding the environmental impacts of footwear production. Identifying resource consumption, waste generation, and emissions throughout the manufacturing stages allows companies to develop targeted strategies for sustainability improvements. The adoption of LCA methodologies aids in quantifying these impacts, guiding the industry toward more environmentally friendly and responsible manufacturing practices. By addressing the environmental challenges associated with manufacturing, the footwear industry can play a significant role in advancing sustainability and contributing to a greener future.

Identification of Opportunities for Process Optimization and Energy Efficiency

To reduce the environmental impact of footwear manufacturing, opportunities for process optimization and energy efficiency can be explored:

- **Lean Manufacturing:** Implementing lean principles to eliminate waste and reduce resource consumption in the manufacturing process.
- **Energy-Efficient Machinery:** Investing in energy-efficient machinery and technologies to reduce electricity consumption and greenhouse gas emissions.
- **Renewable Energy Sources:** Integrating renewable energy sources, such as solar or wind power, to power manufacturing facilities and reduce reliance on fossil fuels.
- **Water Management:** Implementing water recycling and treatment systems to minimize water usage and pollution during the manufacturing process.

Case Studies Showcasing Sustainable Manufacturing Practices Driven by LCA Findings

CASE STUDY 1: Energy-Efficient Manufacturing

Challenge: A footwear manufacturer aimed to reduce its manufacturing energy consumption.

Solution: After conducting an LCA, the company identified energy-intensive processes and invested in energy-efficient machinery. By incorporating advanced technologies and monitoring systems, they reduced energy consumption by 20%, resulting in significant carbon emission reductions.

CASE STUDY 2: Water Management and Pollution Reduction

Challenge: A shoe factory sought to minimize its water consumption and pollution.

Solution: LCA findings revealed that water usage and discharge were key hotspots. The company implemented water recycling and treatment systems, reducing freshwater consumption by 40% and reducing water pollution.

CASE STUDY 3: Lean Manufacturing Implementation

Challenge: A footwear brand wanted to minimize waste in its manufacturing processes.

Solution: After conducting an LCA, the company identified areas of waste generation. They adopted lean manufacturing principles, optimizing material use and reducing waste. This led to a 15% reduction in material waste and improved overall resource efficiency.

In conclusion, evaluating manufacturing processes and optimizing them for energy efficiency and reduced environmental impact is critical in enhancing the sustainability of footwear production. By applying the findings from LCA, companies can identify areas for improvement and implement sustainable manufacturing practices. Case studies showcase successful sustainable manufacturing practices driven by LCA, highlighting the potential for positive change in the footwear industry's environmental performance. Through process optimization, the footwear industry can contribute to a more sustainable and responsible manufacturing sector.

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MODULE 2
SUSTAINABLE RESOURCES AND MATERIALS FOR FOOTWEAR INDUSTRY

BY **ATILLA BASLAR**
TASEV FOUNDATION

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

LECTURE 1
SUSTAINABLE MATERIALS AND COMPONENTS

1.1. INTRODUCTION

Sustainable materials are gaining increasing significance within the fashion industry, particularly in the context of footwear production. Here is an outline to help you begin exploring this topic.
Sustainable materials play a pivotal role in the footwear industry for a variety of compelling reasons: Regarding environmental impact, traditional methods of footwear manufacturing often heavily depend on non-renewable resources, such as petroleum-based plastics and leather production, which can result in deforestation and habitat degradation. Sustainable materials contribute to mitigating these adverse environmental effects.
Today’s footwear approximately is composed of 80-85 % of textile and plastics. The ratio of natural leather which is made of skin and hide in modern-day shoes is like 10-15%. Therefore, circular economy and sustainability perspectives are important in today’s footwear production.
Sustainable materials are often sourced ethically, prioritizing fair labor practices, workers' rights, and animal welfare, thus addressing critical social concerns within the industry.
In terms of consumer demand, as awareness of environmental and social issues continues to grow, consumers are increasingly seeking eco-friendly products, including sustainable footwear. Brands that embrace sustainable materials can attract a broader customer base.
Sustainable materials stimulate innovation in design and production techniques, enabling footwear designers to craft distinctive and environmentally responsible products. This perspective is the main base of our training project, i.e. SHOEDES.

Lecture 2.1 - Sustainable materials and components
Lecture 2.2 - Quality characteristics of "traditional" and “eco-friendly” materials and how to evaluate them
Lecture 2.3 - Quality controls available for sustainable footwear materials

In this unit, we will dwell on sustainable materials used in footwear, quality issues like characteristics, control methods on both traditional and new sustainable materials.

1.2. KEY POINTS: FEATURES OF SUSTAINABLE MATERIALS

Materials and components features to develop more sustainable footwear in summary is as follows:

- Type of material & components (e.g. recycled, recyclable and/or biodegradable).
- Origin and transportation associated.
- Materials (e.g. leather, polymers) produced by eco-friendly processes and that use the minimum amount of chemicals and energy on their production process.

- Water based solvents and glues.
- Lighter, durable and good quality.
- Elimination of unnecessary materials & components.
- Minimization of hazard and restricted substances.
- Material produced with renewable sources.
- Produced by simplified manufacturing production processes.
- Produced with reduced air pollution, water consumption, biodegradation and generation of solid wastes and noise.
- Reused, recycle or valorised at the end of their production and of products life cycle.

Sustainable materials and components

Sustainable materials encompass a diverse range of options within the footwear industry, and among them, recycled materials stand out prominently. Here, we'll delve into two common recycled materials frequently employed in footwear.

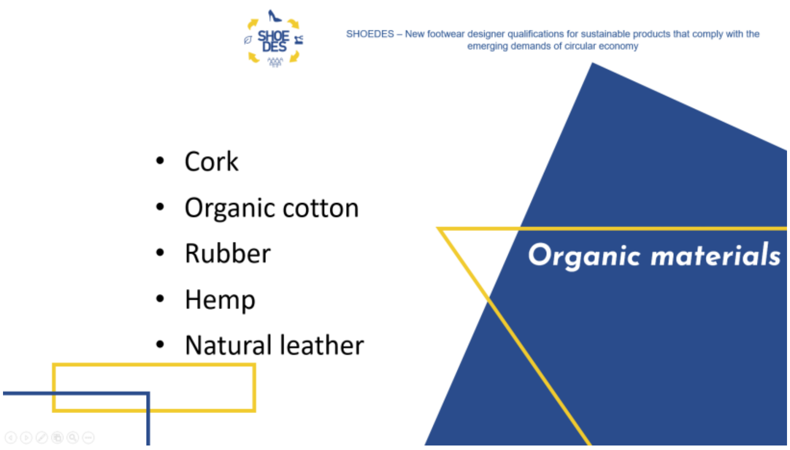
Organic materials are experiencing a surge in popularity within the footwear industry due to their sustainability and eco-friendly characteristics. Natural leather is the most used sustainable material by nature unless it is not processed eco-friendly.

One of the crucial materials used in footwear are polymers like thermoplastic rubber (TPR), polyurethanes (PU), thermoplastic polyurethanes (TPU), Ethylene vinyl acetate (EVA), polyvinylchloride (PVC), among others, in the lower part.
Another innovative approach involves the recycling of old sneakers and footwear to craft new shoes. This entails the collection of worn-out shoes and the utilization of their materials for the creation of new footwear.

Vegan alternatives have gained traction within the footwear industry as sustainable choices that abstain from the use of animal-derived materials.
Innovative sustainable materials are revolutionizing the footwear industry by providing eco-friendly substitutes for conventional materials.

Organic materials

Natural origin materials, are the ones that have origin in nature, like cork, wooden, natural rubber and skin/hide leather or skins of other animals like reptiles or fish.
Cork is a natural product and is used for numerous components but is mainly incorporated into wedges/ and platforms. Depending on the aesthetic requirements or quality (roughness) of cork or cork agglomerate platform may be a requirement of applying an insock. Cork is a renewable and sustainable resource obtained from the bark of cork oak trees. These trees naturally regenerate their bark following harvesting.



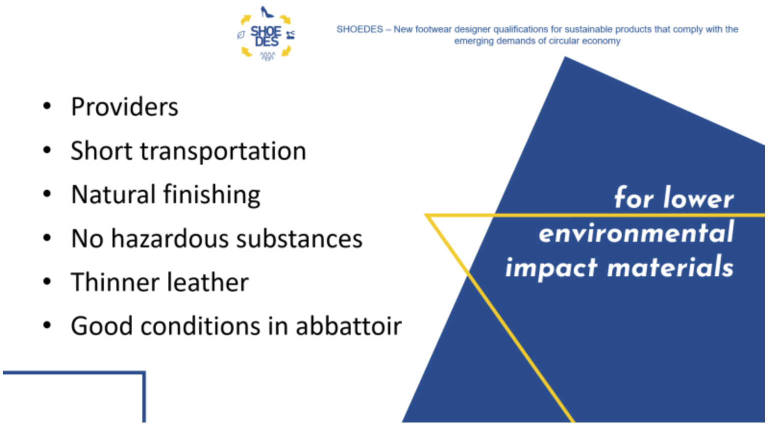
More than 25 percent of the world's pesticides are used in conventional cotton production. Organic cotton is grown without toxic, synthetic chemical inputs. Look for natural dyes or coloured cotton to further reduce the amount of chemicals dumped into our ecosystem. Organic cotton is cultivated without the use of synthetic pesticides or genetically modified organisms (GMOs), promoting healthier ecosystems and reduced chemical usage. Organic cotton farming avoids the harmful pesticides and chemicals associated with conventional cotton cultivation. Organic farming practices prioritize soil health and biodiversity.

Natural rubber is, made by coagulating latex from rubber tree. This soles are very high wear resistant, have good heat insulation properties and are flexible. Natural rubber is constituted by Polyisoprene and has good abrasion resistance and flex cracking.

Hemp is a bast fibre obtained from the stem of the plant. It is a versatile and fast-growing plant, requires minimal water and pesticides. It produces robust and durable fibers suitable for various footwear components. Its fibres are much lower in cellulose content than cotton, but contains hemicellulose and lignin. Hemp cultivation proves environmentally friendly due to its low resource demands. Its fibers are sturdy, making them suitable for various footwear elements, including uppers and laces.
Leather is the oldest / traditional sole material. This kind of soles has been modified and improved by tanners so that a high-quality leather sole is now light, flexible, waterproof and still retains breathability.

For lower environmental impact materials:

Here are some r**ecommendations for lower environmental impact for natural leather**
Select leather from companies that accomplish ecological criteria and requirements; sustainable processes and good environmental practices.



- Select leather companies that use skin raw material from countries in close proximity to decrease the transportation carbon footprint.
- Use of more natural leather without too much finishing products applications.
- Use high quality and durable leather.
- Use of leather without restricted and hazardous substances.
- Use thinner leather materials
- Good use of leather area during the cutting process to reduce the leather waste

Recycled plastic products

The ecological part weighs increasingly on the shoe-making worldwide, and there is already a lot of companies focusing on recyclable materials, particularly for the soles. "More than 60% of the soles used today seem rubber are actually made of thermoplastic and recyclable materials. Even when using rubber tries always to be also recycled.
Recycled PU (Polyurethane), Thermoplastic Polyurethane (TPU) or PET (polyethylene terephthalate) or polyesters stands as a popular choice for sustainable footwear production. Plastic bottles undergo collection, cleansing, and processing to form yarn or fabric utilized in shoe uppers.

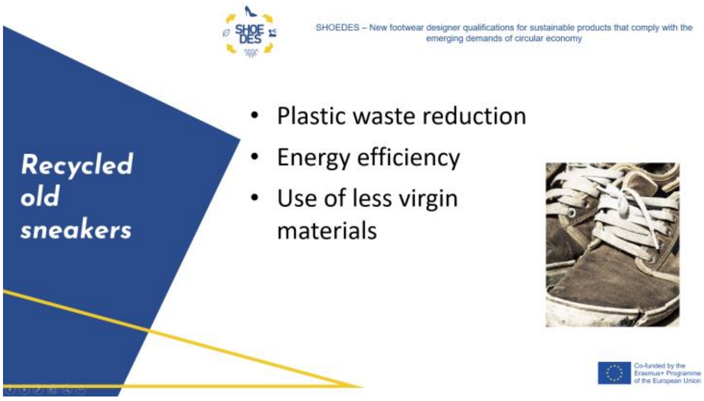
Benefits of recycled PET is given below:

Plastic waste reduction: By repurposing PET bottles, the footwear industry contributes significantly to mitigating plastic pollution.

Lightweight and durable: Recycled PET materials offer the advantage of being lightweight while providing durability akin to traditional materials.

Energy efficiency: The recycling process for PET consumes less energy compared to the production of virgin materials.

The fibres which are made from cast-off polyester fabric and soda bottles, resulting in a carbon footprint that is 75 percent lower than virgin polyester. Recycled polyester contains toxic antimony, but some companies are working on removing it from their fabrics.



Recycled old sneakers

Another innovative approach involves the recycling of old sneakers and footwear to craft new shoes. This entails the collection of worn-out shoes and the utilization of their materials for the creation of new footwear. The benefits may be summarized as follows:

Circular economy promotion: Recycling old sneakers fosters a circular economy by extending the lifespan of materials and diminishing waste.

Reduced raw material demand: The use of recycled sneakers lessens the necessity for fresh resources, thereby contributing to resource conservation.

Unique design possibilities: Each batch of recycled sneakers can yield distinct color combinations and designs.

Certain brands like Converse and Etnies have ventured into recycling old sneakers to produce limited-edition lines of footwear.

These sustainable materials not only assist in mitigating the environmental impact of footwear production but also convey a powerful message concerning the significance of recycling and waste reduction within the fashion industry.

Vegan leathers

Vegan leathers are made from innovative and sustainable materials such as pineapple leaves, cork, apple peels, cactus or other fruit waste, and recycled plastic and used to create products that put animal skins to shame. Those artificial leathers which are made of polymers like PU or PVC are commonly called as vegan in quotation since those materials are not from animal origin.

Vegan alternatives have gained traction within the footwear industry as sustainable choices that abstain from the use of animal-derived materials.

The production process of vegan leather does not negatively affect the environment but the materials obtained have very **important limits of use and quality** compared to genuine leather which we can summarize in the following points:

- **Poor strength and durability**, vegan leather lasts much less than real leather.
- **Poor workability and versatility**, vegan leather is only suitable for the production of certain objects.
- **High production costs**, even though vegan leather is a recycled material, it can cost more than one square meter compared to real leather.
- **Poor quality and feel**, vegan leather is not comparable to real leather from a qualitative point of view.
- **It is not zero impact**, that is, it is not 100% sustainable, as means and machinery that have fossil fuels as their energy source are often used for its production.

Innovative materials

Innovative sustainable materials are revolutionizing the footwear industry by providing eco-friendly substitutes for conventional materials. Two noteworthy examples include mushroom leather and pineapple leather, also known as Piñatex.

Mushroom leather is crafted from mycelium, the root structure of mushrooms. It stands as a rapidly renewable and biodegradable material. Mycelium can be cultivated swiftly with minimal resource requirements in controlled environments, thereby reducing its environmental footprint. Regarding biodegradability, mushroom leather fully biodegrades, minimizing waste at the end of its lifecycle. It can be cultivated in various shapes and sizes to suit specific footwear designs.
Pineapple Leather, Piñatex, is derived from the fibres of pineapple leaves, a byproduct of the pineapple industry. It presents an innovative and sustainable alternative to traditional leather. repurposes agricultural waste, reducing the environmental impact of pineapple farming. It aligns with

vegan values and avoids the use of animal-derived materials, so it can be perceived as vegan leather. In terms of durability ‘t is robust and suitable for various footwear components, including uppers and linings.
There are various new eco-friendly fibres. Seacell, a fibre, is derived from wood pulp and seaweed (algae) and diffuses its protective and anti-inflammatory properties into the skin, stimulating the metabolism.

Lenpur, which is biodegradable fabric is made from white pine tree clippings, and "offers the comfort of silk, the touch of cashmere and the lightness of linen." Lenpur's website states that it's a cut above the other cellulose fibres due to its softness, its absorption capacity and ability to release dampness, and its ability to sustain a higher thermal range —thus keeping your feet cooler in the summer and warmer in the winter.

SoySilk, a lesser known 100% biodegradable ecofriendly fabric is made from tofu-manufacturing waste. Soy protein is liquefied and then stretched into long, continuous fibres that are cut and processed like any other spinning fibre. Because soy has high protein content, the fabric is very receptive to natural dyes, so there's no need for synthetic dyes.
STINGplus Nettle Fabric is woven from the stinging nettle, which "produces a uniquely strong, soft and naturally fire-retardant textile fibre" and, blended with pure new wool, it is "the ultimate environmental upholstery solution.“

In fact, these innovative materials form part of an emerging trend in the footwear industry that explores sustainable and renewable material sources and the sky is the limit.

2.1 Challenges in Implementing Sustainable Practices

Regarding the challenges in implementation of sustainable practices in footwear sector, it requires collaboration and coordination throughout the supply chain, including sourcing, production, and distribution.
The development of sustainable materials and production processes may face technological challenges, such as finding validated and internationally accepted alternatives to chemical-intensive treatments.
The one of the challenges but not the last is the level of consumer demand for sustainable footwear, although it is growing, there is still a need to educate consumers about the benefits and value of sustainable footwear products in order to support conscience.

1.3. CONCLUSION

In brief, there are various types of sustainable materials which encompass a diverse range of options for the footwear industry, and among them, recycled materials stand out prominently. In this lecture we have delved into organic materials which are experiencing a surge in popularity within the footwear industry due to their sustainability and eco-friendly characteristics and those crucial materials used in footwear are polymers like thermoplastic rubber (TPR), polyurethanes (PU), thermoplastic polyurethanes (TPU), Ethylene vinyl acetate (EVA), polyvinylchloride (PVC), among others, in the lower part which are re-useable and recyclable. Another innovative approach is the recycling of old sneakers and footwear to craft new shoes. This entails the collection of worn-out shoes and the utilization of their materials for the creation of new footwear.

LECTURE 2
QUALITY CHARACTERISTICS OF "TRADITIONAL" AND ECO-FRIENDLY MATERIALS

2.1. INTRODUCTION

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- Lecture 2.1 - Sustainable materials and components
- Lecture 2.2 - Quality characteristics of "traditional" and “eco-friendly” materials and how to evaluate them
- Lecture 2.3 - Quality controls available for sustainable footwear materials

In this lecture, we will dwell on quality issues like characteristics, control methods on traditional and new eco-friendly materials used in footwear.

2.2. QUALITY CHARACTERISTICS OF “TRADITIONAL” MATERIALS

The properties and quality of natural leather as a traditional material depends on the raw materials (hides or skins quality) and manufacturing process, since the beamhouse stage to finishing. The manufacturing process of leather is designed considering the desired requirements for shoe in terms of aesthetic, physical and chemical properties, keeping an eye on the associated costs.

Traditional material quality aspects are mainly focusing on the material itself like applicability of the material in product. Besides that, production related quality matters like cost minimization or reducing losses are important within the perspective of demanded quality issues of the customer. The customer point of view is important in traditional total quality management and therefore, the internal and external customers needs and demands are taken into consideration.

But in new way of quality management focusing on sustainability and circular economy requires beyond the traditional understanding of total quality management like renewability, recyclability, lower environmental impact or social responsibility taking into consideration of sustainability of economic resources and business life cycle.

Natural leather quality control is essential to guarantee the quality of shoe products in terms of physical resistance and comfort, as well as to avoid the presence of hazardous substances that can be prejudicial or are forbidden for people and environment. As the requirements depends on the shoe final application.

Natural leather for upper

In terms of quality control issues of upper, natural leather should stretch during the shoe manufacturing and wear. It is essential to guarantee a suitable flex resistance and tear strength of natural leather, including the handling and final lasting, avoding the break of finishing and material itself.

The elasticity property of natural leather is important to give the shape to a 2D material into a 3D formation and get a stable shape, after the last is removed. Besides that, during wear the shoe is constantly subjected to flexion and should remmeber its original shape when it is taken out from the foot.

The delamination during wear should be avoided by a good adhesion of finish to leather surface.

Bondability is to ensure a good adhesion between the upper and sole and resistance during the stitching process and wear.

Especially during the wear, abrasion resistance is important to prevent the loss of colour and maintain the original aspect of leather. If the shoe has not lining material, it is necessary prevent the staining of socks or users' feet.

During the shoe manufacturing process, leather is subjected at high temperatures especially for the purpose of durable adhasion, so the leather has to have resistance to these temperatures to prevent the shrinkage and break during the drying operations.

The comfort depends on the humidity inside the shoe during the wear due to transpiration, so the leather should be capable to release the water vapour to the outside (keeping the outdoor water away). The finishing applied on leather surface can prejudice the breathable properties that characterize leather materials.

The water resistance is a property required in special applications, such as protective or outdoor footwear.

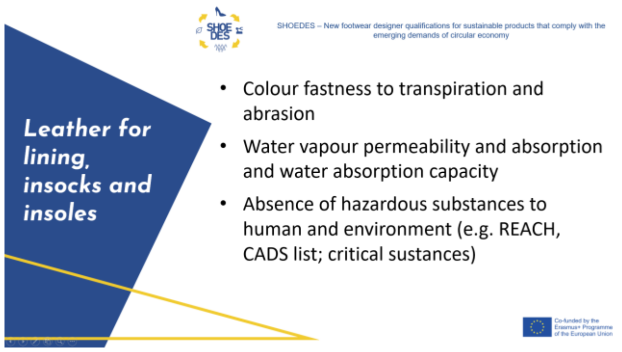
To prevent salts migration to the surface is another quality feature to look for in natural leather.

Hazardous substances to human health and environment which are regulated by REACH and CADS list should be kept away.

Leather for lining, insocks and insoles

The materials which are in direct contact with the foot are lining and insock materials and very influent for the footwear comfort. In general, lining materials should present physical resistance properties, but normally with less demanding requirements than the established for natural leather upper. The main properties of lining materials are:

Colour fastness, abrasion, Water vapour permeability and absorption, water absorption capacity and absence of hazardous substances to human and environment which are regulated in such as REACH, CADS etc.



Leather for outsoles

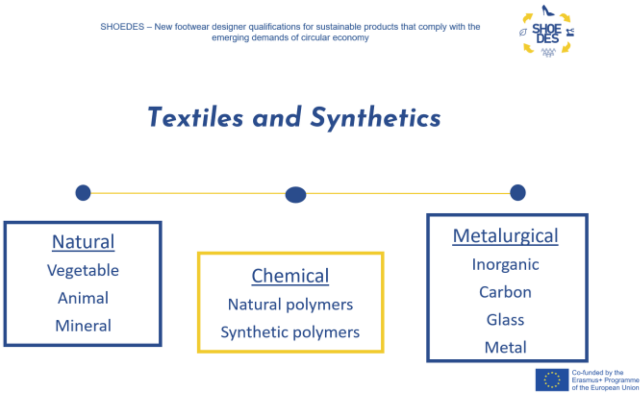
Leather outsole is mostly used in high quality shoes. Normally, natural leather outsole is manufactured by vegetable tanning process, due to its characteristics, such as moldability and higher rigidity. These properties are essential for the comfort and physical resistance required to outsoles. The main properties of leather outsoles are:

Flexibility and dimensional stability to avoid the breaking and stability during use, t**ear strength and abrasion resistance t**o guarantee physical resistance and performance during use, **bondability and**

needle tear strength to guarantee the linkage between the upper part and the sole, **Water resistance to** prevent water penetration through sole and **absence of hazardous substances to human and environment** (e.g. REACH, CADS list; critical substances)

Textiles and Synthetics

Textile materials refers to materials that are susceptible of being transformed in yarns and posterity in woven. These materials are, essentially, all types of fibres of **natural** origin (vegetable, animal or mineral), **chemical** origin (obtained from natural and synthetic polymers) or **metallurgical** origin (obtained from inorganic substances by metallurgical technology).



The textile materials properties depend on several factors, namely:

- Type of fibre;
- Fibre dimension;
- Type of yarn;
- Fibre diameter;
- Construction method of textile;
- Type of finishing.

Natural fibres are made from plant, animal and mineral sources. The natural fibres can be classified into three chemical classes: Cellulosic, which are the fibres obtained from various parts of plants, such as the stems (bast fibres), leaves and seeds.
Protein (keratin) fibres, which are the fibres obtained from wool and hair and silk.
Mineral (the only naturally occurring mineral fibre is asbestos but its use is banned in many countries because of its toxicity).
The man-made be sub-divided into three broad groups:

- 'Regenerated' fibres, which are fibres derived from natural sources comprising organic polymers by chemical processing to both extract the fibre-forming polymer and to impart novel characteristics to the resulting fibres.
- Synthetic fibres that are produced from mainly from petroleum.
- Inorganic fibres, such as ceramic and glass fibres.

Textiles used in footwear

The quality control for textiles used in footwear, must be basically the same as that used for the leather. The characteristic of uppers, insoles, insocks and linings, in the shoe must maintain the properties, regardless of the material, namely:
Flexibility and dimensional stability dimension: Textile/synthetic is subjected to flexion and stretch during the shoe manufacturing and wear, being essential to guarantee a suitable flex resistance and

tear strength, considering the handling and final application, to avoid the break of finishing and material itself.

The elasticity property of textile/synthetic is important to mould the 2D material in a 3D construction and get a permanent shape, even after the last is removed. On the other hand, during wear the shoe is constantly subjected to flexion and should recover its original shape when it is removed from the foot. In this way it is necessary combine in a proper way the elasticity and plasticity properties to get a suitable shoe product.

The delamination during wear should be avoided by a good adhesion of finish to textile/synthetic surface.

Bondability and needle tear strength is sought to ensure a good adhesion between the upper and sole and resistance during the stitching process and wear.

Colour fastness and abrasion resistance is another feature looked for preventing the loss of colour and maintain the original aspect of textile/synthetic. If the shoe has no lining material, it is necessary prevent the staining of socks or users' feet.

During the shoe manufacturing process, textile/synthetic is subjected at high temperature, so the material has to have resistance to these temperatures to prevent the shrinkage and break during the drying operations.

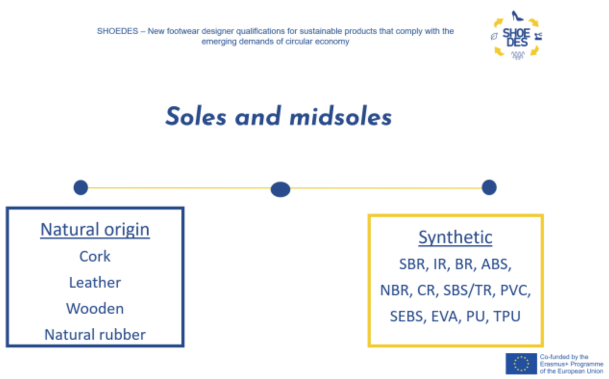
The comfort depends on the humidity inside the shoe during the wear due to transpiration, so the textile/ synthetic should be capable to release the water vapour to the outside. The finishing applied on material surface can prejudice the breathable properties that characterize leather materials. And the last feature for quality check is **absence of hazardous substances to human and environment** like azo-dyes, chromium VI, formaldehyde, heavy metals or organic tin.

Soles and midsoles

The sole, can be a distinguish factor for footwear, its design and special features, formulation and composition contributes for specific function.

The sole is one of the most important part of footwear which must be durable against indoor-outdoor conditions. It´s first function is to prevent the damage of the floor could make to the feet. The footwear sole also provides the absorption of energy during the walking, protects the feet from heat

and cold and can be extremely important for supporting certain activities, like running, hiking, walking, etc.
There are many types of procedures and technologies associated to the production of types of soles. The sole and midsole materials could be based in several material that could be divided by:
Natural origin materials and Synthetic origin materials .



The kind of sole depends on such factors as consumer and buyer demands, fashion, ease of manufacture, price, durability, and a satisfactory source of supply.

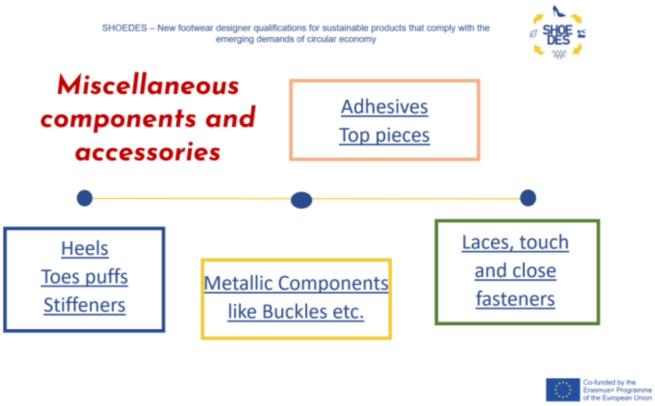
Soles and midsoles used in footwear

The quality control for soles and midsoles used in footwear, must be basically the same as that used for the leather. The characteristic of uppers, insoles, insocks and linings, in the shoe must maintain the properties, regardless of the material, namely:

- **Flex resistance** to avoid the breaking and stability during use.
- **Tear strength and abrasion resistance** to guarantee physical resistance and performance during use,
- **Slip resistance** to avoid slip and falls on ceramic floor and water and detergent,
- **Delamination resistance or slip tear (only for multilayer soles)** to be avoided by a good adhesion of multilayer soles,
- **Dimensional stability** to guarantee the dimensions on soles,
- **Compression energy** to guarantee that there’s a good heel energy absorption,
- **Bondability (only for sewn footwear)** to guarantee the linkage between the upper part and the sole,
- **Water soluble substances content** to prevent salts migration to the surface,
- **Water resistance** to prevent water penetration through sole,
- **Needle tear strength** to prevent objects penetration through sole,
- **Resistance to oils** to prevent sole degradation when in contact with oils,
- **Flame resistance** to guarantee flame protection of user during use,
- **Antistatic or conductive properties** to guarantee electrical protection of user during use and
- **Absence of hazardous substances to human** like Heavy metals, phthalates, azo-dyes, chromium VI, formaldehyde.

Miscellaneous components and accessories

One of the integral part of footwear is components and accessories of which some of them visible and some of them hidden They are adhesives, top pieces, heels toe puffs, stiffeners, laces, fasteners and etc.



During the various operations of shoe production, are many and diverse adhesives that can be used which are solvent based, water based, holt-melt and reactive liquids. Those petroleum based adhesives contributes to environmental pollution. Water based adhesives, don't have the dangers to health and environment as the solvent based adhesives because of their water composition.

Toe puffs reinforce the toe end of the shoe upper, and stiffeners retain shape and provide support at the back of the shoe. The most used materials for toe puffs and stiffeners are thermoplastics sheets, recyclable (100% recycled fibres), natural (e.g. cellulose fibres).

Metallic components in footwear manufacture are buckles, shanks, spikes, toe puffs, zippers, midsoles, eyelets, adomments, buttress, i.e. Some them are for design purposes and some for mantling the shoe.

The wide range of footwear, from lightweight fashion shoes to heavy work boots, demands a correspondingly wide range of reinforcements like stiffeners and toe puffs to satisfy practical and aesthetic needs.

Many different heel types are used in modern footwear. The most common type for women's shoes is injection moulded plastic, although turned wood heels and built heels are still used like chunky, stiletto, built and heel attachments.

Regarding those components and accessories, the bondability, mechanical characteristics, impact resistance

flex resistance, abrasion resistance, slip resistance and absence of hazardous substances are those criteria foreseen in general. Plus, for metallic components corrosion resistance has been sought for.

Miscellaneous components and accessories

Upto now, we had discussed the "traditional way of quality standards regarding natural leathers. From now on, we will dwell on evaluation of suitability of eco-friendly materials from the point of sustainability and circular economy.

Evaluating materials based on these characteristics can help individuals and industries make more sustainable choices, contributing to environmental conservation and responsible consumption. Keep in mind that the specific criteria for eco-friendliness may vary depending on the context and the intended use of the materials.

When considering the quality characteristics of "eco-friendly" materials from a circular economy perspective, the focus is on designing products and materials that promote sustainability by minimizing waste and maximizing resource efficiency. Here are key quality characteristics in this context:

In terms of **Recyclability**, the important perspectives are as follows

- **Closed-Loop Recycling:** Materials that can be easily recycled and reintroduced into the production cycle without a loss in quality.
- **Design for Disassembly:** Products and materials designed for easy separation and recovery of components at the end of their life.
- Regarding **Upcycling,**
- **Value Retention i.e.** Materials that can be upgraded or transformed into higher-value products during the recycling or repurposing process and
- **Creative Reuse:** which means designing materials to have multiple life cycles by encouraging creative and innovative reuse are elaborated.
- **Bio-Based Materials** are derived from renewable resources that can be regrown or replenished. **Biodegradability** is focusing on materials that can naturally decompose into environmentally harmless substances, closing the nutrient loop.
- **Product Longevity** aspects are:
- **Durable Design** focusing on creating products with a focus on longevity to extend the time between replacements or upgrades and
- **Modularity** which is designing products with interchangeable and upgradeable parts to extend their life.
- Minimization of **Residual Waste** when discarded, aims producing minimal waste or pollutants and
- **Zero or Low Waste Manufacturing** aims to generate minimal waste during manufacturing.
- **Reverse Logistics** is crucial in terms of:
- **Take-Back Systems** i.e. Implementation of systems where manufacturers take back used products for proper disposal, recycling, or refurbishment and
- Manufacturers look after **End-of-Life Responsibility** by taking responsibility for the proper disposal and recycling of their products.

- In terms of **Digital Technologies:**
- **Tracking and Tracing** is an integral part. Integration of technologies (like blockchain, RFID or QR codes) to track materials and products through their life cycle, enabling efficient recycling or repurposing.
- **Data Analytics for Optimization** using data analytics to optimize material flows, reduce waste, and improve resource efficiency.
- **Product as a Service (PaaS)** is a shift from ownership to service models where products are leased or rented, encouraging manufacturers to design for durability and reuse.
- Encouraging shared use of products, reducing the overall demand for new materials is main focus of **Collaborative Consumption** .
- **Certifications and Standards** such as
- **Circular Economy Certifications** which is working on recognition from organizations certifying adherence to circular economy principles and
- **Compliance with Circular Design Guidelines which a**dhere to guidelines that promote circular design principles are important from circular point of view.
- **Resource Efficiency** by **Optimized Resource Use** i.e. minimizing resource inputs in production processes and **Efficient Material Use to m**aximize the utility of materials to minimize waste are very important for reducing use of economic resources.

Considering these characteristics in the design, production, and disposal of materials can contribute to a more circular and sustainable economy by reducing waste, conserving resources, and encouraging responsible consumption and production practices. These are the main aspects of quality regarding eco-friendly materials.

2.3. CONCLUSION

In brief, there are various types of quality aspects of sustainable materials which encompass a diverse range of options for the footwear industry, both traditional and new, eco-friendly materials.
In this lecture we have delved into

- material quality
- No hazardous material
- Zero mistake in manufacturing
- Cost minimization

In terms of eco-friendly materials which are experiencing a surge in popularity within the footwear industry due to their sustainability and characteristics, quality aspects, such as environmental points like waste reduction, recyclability, upcycling, biodegradability are important. In terms of carbon footprint, product longevity, reverse logistics, collaboration and sharing models, low Environmental Impact, energy and water efficiency, digital technologies are taken into consideration. From social point of view, ethical labor practices and social responsibility is elaborated.

LECTURE 3
QUALITY CONTROLS FOR SUSTAINABLE FOOTWEAR MATERIALS

3.1. INTRODUCTION

Sustainable materials stimulate innovation in design and production techniques, enabling footwear designers to craft distinctive and environmentally responsible products. This perspective is the main base of our training project, i.e. SHOEDES.

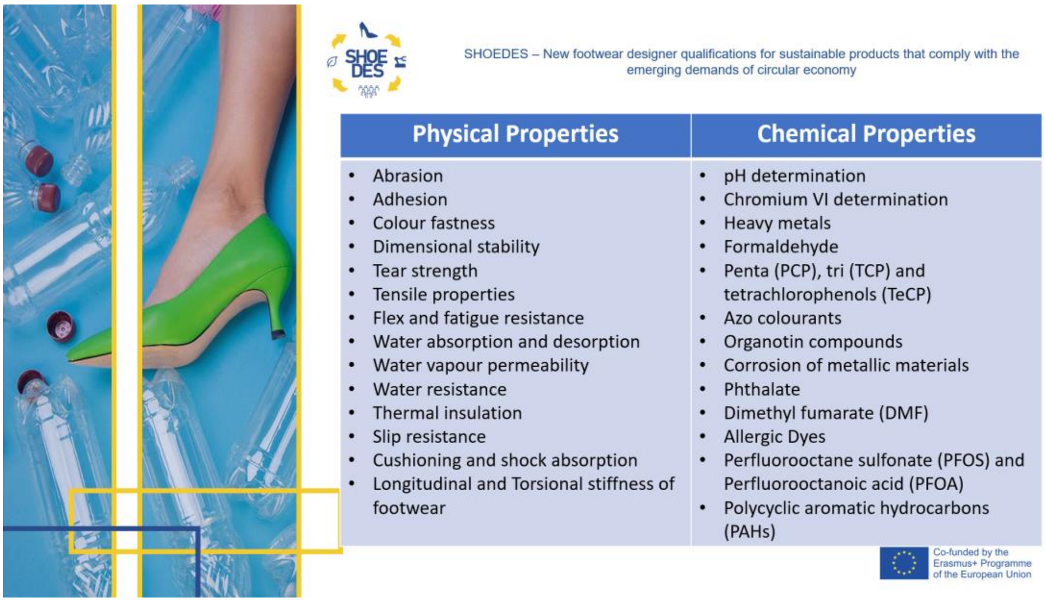
Lecture 2.1 - Sustainable materials and components

Lecture 2.2 - Quality characteristics of "traditional" and “eco-friendly” materials and how to evaluate them

Lecture 2.3 - Quality controls available for sustainable footwear materials

Sustainable materials are gaining increasing significance within the context of footwear industry and quality controls for sustainable footwear materials have new dimensions other than the traditional materials used in footwear.

In this lecture, we will dwell on quality control requirements for eco-friendly footwear materials. Making tests is essential to guarantee the footwear final performance. This chapter describes briefly the most relevant new style tests dedicated to eco-friendlyness. We will be looking at EU COMMISSION DECISION no: 2016/1349 of 5 August 2016 regulating the establishment of the ecological criteria for the award of the EU Ecolabel for footwear.



Physical Properties	Chemical Properties
• Abrasion • Adhesion • Colour fastness • Dimensional stability • Tear strength • Tensile properties • Flex and fatigue resistance • Water absorption and desorption • Water vapour permeability • Water resistance • Thermal insulation • Slip resistance • Cushioning and shock absorption • Longitudinal and Torsional stiffness of footwear	• pH determination • Chromium VI determination • Heavy metals • Formaldehyde • Penta (PCP), tri (TCP) and tetrachlorophenols (TeCP) • Azo colourants • Organotin compounds • Corrosion of metallic materials • Phthalate • Dimethyl fumarate (DMF) • Allergic Dyes • Perfluorooctane sulfonate (PFOS) and Perfluorooctanoic acid (PFOA) • Polycyclic aromatic hydrocarbons (PAHs)

For footwear materials, the physical and chemical properties are to be validated which may include a few hundreds of different chemical and physical tests. Those tests are elaborated in general in previous lesson. Besides those tests, eco-friendly materials may require some other quality criteria to be tested which will be given from now on.

3.2. EU ECOLABEL CRITERIA

The revised ecological criteria aim of EU Ecolabel, in particular, is promoting products that have a lower environmental impact mainly in terms of depletion of natural resources, emissions to water, air and soil from manufacturing processes and which contribute to the environmental dimension of sustainable development along their life cycle, are durable, and restrict the presence of hazardous substances.

The revised criteria also promote the social dimension of sustainable development by introducing requirements regarding labour conditions at the final assembly site, with reference to the International Labour Organisation's (ILO) Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, the UN Global Compact, the UN Guiding Principles on Business and Human Rights and the OECD Guidelines for Multi-National Enterprises.

SHOEDES – New footwear designer qualifications for sustainable products that comply with the emerging demands of circular economy

Criteria	Sub-Criteria
1 - Origin of hides and skins, cotton, wood and cork, and man-made cellulose fibres	1.1 - Requirements on hides and skins 1.2 - Cotton and other natural cellulosic seed fibres 1.3 - Sustainable wood and cork 1.4 - Man-made cellulose fibres (including viscose, modal and lyocell) 1.5 - Plastics
2 - Reduction of water consumption and restrictions on tanning of hides and skins	2.1 - Water consumption 2.2 - Restrictions in tanning of hides and skins
3 - Emissions to water from the production of leather, textile, and rubber	3.1 - Chemical Oxygen Demand (COD) in wastewater from leather tanning sites 3.2 - Chemical Oxygen Demand (COD) in wastewater from textile 3.3 - Chemical Oxygen Demand (COD) in wastewater from processing of natural and synthetic rubber 3.4 - Chromium in tannery waste water after treatment
4 - Volatile Organic Compounds (VOCs)	
5 - Hazardous substances in the product and shoe components	5.1 - Restriction of Substances of Very High Concern (SVHC's) 5.2 - Restriction based on CLP[8] hazard classifications
6 - Restricted Substances List (RSL)[9]	
7- Parameters contributing to durability	
8 – Corporate Social Responsibility with regards to labour aspects	
9 – PackagingCriterion 8 - Corporate Social Responsibility with regard to labour aspects	9.1 - Cardboard and paper 9.2 – Plastic
10 - Information on the packaging	10.1 - User Instructions 10. - Information appearing on the eco-label

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By EU Ecolabel, the product group ‘footwear’ shall comprise all articles designed to protect or cover the foot, with an applied sole which comes into contact with the ground.

The product group shall not comprise following products:

- footwear containing any electric or electronic components;

- footwear that is disposed of after a single use;
- socks with an applied sole;
- toy footwear.

The detailed assessment and verification requirements are required from the applicant such as declarations, documentation, analyses, test reports, or other evidence to show compliance with the criteria. These may originate from the applicant or his or her supplier(s) or their suppliers, as appropriate.

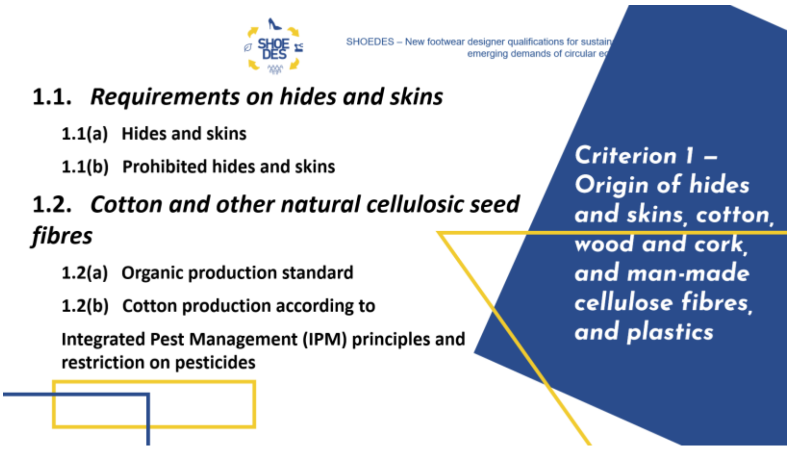
The final product is one pair of shoes. Requirements are based on shoe size: 42 Paris point for men, 38 Paris point for women, 40 Paris point for unisex models, 32 Paris point for children (or the largest size in the case of sizes smaller than 32 Paris point), and 26 Paris point for children under three years of age.

Criterion 1 — Origin of hides and skins, cotton, wood and cork, and man-made cellulose fibres, and plastics

Raw hides and skins destined to be used in a final footwear product shall be subject to the restrictions specified in criteria in 2 sub-criteria. Criterion 1.1(a) shall apply when the leather content in shoe uppers or shoe outer soles is greater than 10,0 % weight by weight of either component.

Only raw hides and skins from animals raised for milk or meat production are allowed to be used in footwear.

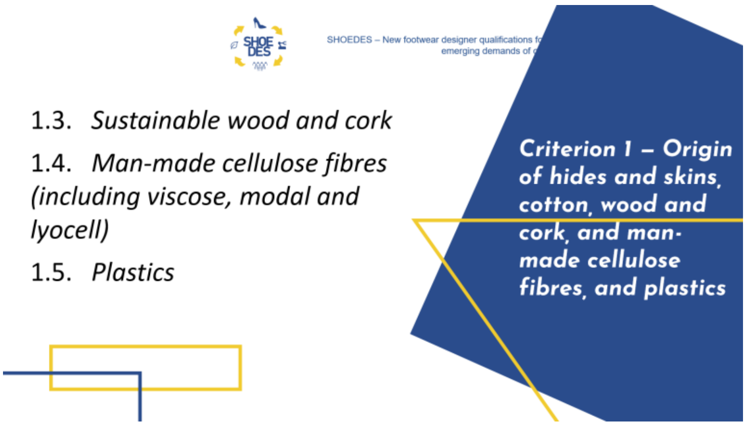
Raw hides and skins originating from extinct, extinct in the wild, critically endangered, endangered, vulnerable, and near threatened species, according to the categories established by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, shall not be used in the final product. The applicant shall submit a declaration of compliance from the leather manufacturer or the hides or skins supplier for ***Assessment and verification***.



For 2nd criterion, ***Cotton and other natural cellulosic seed fibres,*** applies when the cotton content in shoe uppers or shoe outer soles is greater than 10,0 % weight by weight of either component. Cotton that contains 70,0 % weight by weight or more of recycled content is exempted from the requirement of criterion 1.2.

Cotton and other natural cellulosic seed fibres (hereinafter referred to as cotton) that are not recycled fibres shall contain a minimum content of either organic cotton (see criterion 1.2(a) or integrated pest management (IPM) cotton (see criterion 1.2(b)). Textiles that have been awarded the EU Ecolabel based on the ecological criteria of Commission Decision 2014/350/EU are considered to

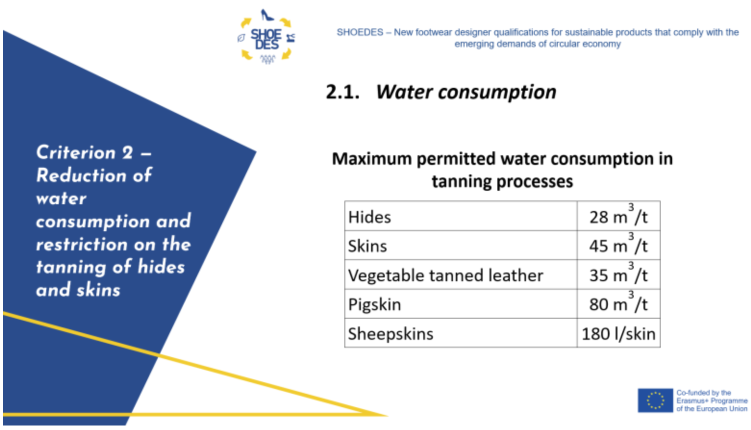
comply with criterion 1.2. The applicant shall submit a declaration of compliance from the supplier for ***Assessment and verification***.
Where applicable, recycled content shall be traceable back to the reprocessing of the feedstock provided the third-party certification.
With the exception of footwear intended for children under three years of age, a minimum of 10 % weight by weight of the non-recycled cotton fibre used in the product At least 95 % w/w of the non-recycled cotton fibre used in footwear intended for children under three years of age shall be organic cotton. Organic content claims may only be made when the organic content is a minimum of 95 %.
In terms of ***Assessment and verification,*** the applicant or material supplier, as appropriate, shall provide a declaration of compliance for the organic content supported by evidence certified by an independent control body to have been produced in conformity with the production and inspection requirements laid down in Regulation (EC) No 834/2007, the US National Organic Programme (NOP) or those set by other trading partners. Verification shall be provided for each country of origin.
For criteria 1.2.(b), with the exception of footwear intended for children under three years of age, a minimum of 20 % weight by weight of the non-recycled cotton fibre used in the product. At least 60 % of the non-recycled cotton fibre used in footwear intended for children under three years of age shall be grown according to IPM principles.
IPM cotton destined for use in the final product shall be grown without the use of any of the following substances: aldicarb, aldrin, camphechlor (toxaphene), captafol, chlordane, 2,4,5-T, chlordimeform, cypermethrin, DDT, dieldrin, dinoseb and its salts, endosulfan, endrin, heptachlor, hexachlorobenzene, hexachlorocyclohexane (total isomers), methamidophos, methylparathion, monocrotophos, neonicotinoids (clothianidine, imidacloprid, thiametoxam), parathion, pentachlorophenol.
For ***Assessment and verification,*** the applicant or material supplier, as appropriate, shall provide a declaration of compliance with criterion 1.2(b), supported by evidence that at least 20 % weight by weight of the non-recycled cotton fibre contained in the product, or 60 % weight by weight in the case of footwear intended for children under three years of age, has been grown by farmers that have participated in formal training programs of the UN FAO or Government IPM or ICM programs.



For ***Sustainable wood and cork,*** criterion 1.3, shall apply when the wood or cork content used in shoe uppers or shoe outer soles is greater than 10,0 % weight by weight of either component. All wood and cork shall be covered by chain of custody certificates issued by an independent third-party certification scheme such as the Forest Stewardship Council (FSC), the Programme for the Endorsement of Forest Certification (PEFC) or equivalent.

All virgin wood and cork shall not originate from GMO species and shall be covered by valid sustainable forest management and chain of custody certificates issued by an independent third-party certification scheme such as FSC, PEFC or equivalent.
Where a certification scheme allows the mixing of uncertified material with certified and/or recycled materials in a product or production line, a minimum of 70 % of the wood or cork material, as appropriate, shall be sustainable certified virgin material and/or recycled material.
For ***Assessment and verification***, the applicant or material supplier, as appropriate, shall provide a declaration of compliance supported by valid, independently certified chain of custody certificate(s) for all wood and cork material used in the product or production line and demonstrate that at least 70 % of the wood or cork material originates from forests or areas managed according to sustainable forest management principles and/or from recycled sources.
For ***Man-made cellulose fibres,*** criterion 1.4 shall apply when the man-made cellulose fibre content used in shoe uppers or shoe outer soles is greater than 10,0 % weight by weight of either component. Man-made cellulose fibres that contain 70,0 % weight by weight or more of recycled content are exempted from the requirement. A minimum of 25,0 % of the non-recycled pulp fibres shall be manufactured from wood that has been grown according to the principles of sustainable forest management as defined by the UN FAO. Textile products that have been awarded the EU Ecolabel based on the ecological criteria of Decision 2014/350/EU are considered to comply with criterion 1.4.
Regarding *Assessment and verification:* the applicant or material supplier, as appropriate, shall provide a declaration of compliance.
In terms of plastics, PVC shall not be used in any part of the product. Its ***Assessment and verification*** is based on the applicant or material supplier's, as appropriate, provision of ta declaration of compliance.

Criterion 2 — Reduction of water consumption and restriction on the tanning of hides and skins

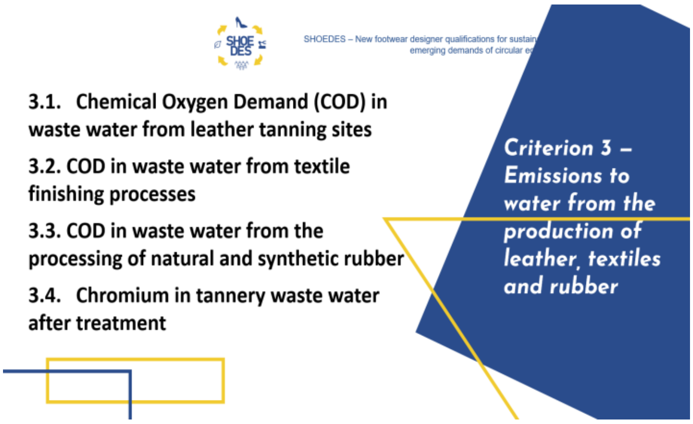


Raw hides and skins that are destined to be used in the final product shall be subject to the limit on **water consumption in the tanning**. The criterion shall apply when the leather content used in shoe uppers or shoe outer soles is greater than 10,0 % weight by weight of either component. Water consumption expressed as the annual average volume of water consumed per tonne of raw hides and skins shall not exceed the limits given in Table above.
For ***Assessment and verification,*** the applicant shall provide a declaration of compliance from the leather supplier or leather manufacturing company.

For **Criterion 2.2.** ***Restriction on the tanning of hides and skins,*** leather used in products intended for children under three years of age shall be subject to the restriction on chromium-based tanning. For footwear intended for children under three years of age, raw hides and skins destined to be used in linings and socks, shall be processed using chromium-free tanning technology.
For ***Assessment and verification,*** the applicant shall provide a declaration of compliance from the leather supplier or leather manufacturing company.

Criterion 3 — Emissions to water from the production of leather, textiles and rubber

The criterion shall apply whenever the leather, textile or rubber content, as appropriate, is used in shoe uppers or shoe outer soles and is greater than 10,0 % weight by weight of either component.



- ***Chemical Oxygen Demand (COD)*** **value in waste water from leather tanning sites**, when discharged to surface waters after treatment (whether on site or off site), shall not exceed 200,0 mg/l.

In terms of ***Assessment and verification,*** the applicant or material supplier, as appropriate, shall provide a declaration of compliance supported by detailed documentation and test reports in accordance with ISO 6060 showing compliance with this criterion on the basis of monthly averages for the six months preceding the application.

- **The COD value in waste water discharges from textile finishing processes** shall not exceed 20,0 g/kg of textiles processed. Finishing processes shall include the thermosetting, thermosoling, coating and impregnating of textiles. This requirement shall apply to wet processes used in the finishing of the textile fabric. The requirement shall be measured downstream of an on-site waste water treatment plant or a municipal waste water treatment plant receiving waste water from these processing sites.

For ***Assessment and verification,*** the applicant or material supplier, as appropriate, shall provide a declaration of compliance/ Where EU Ecolabel textile products are used, the applicant shall provide a copy of the EU Ecolabel certificate showing that it was awarded in accordance with Decision 2014/350/EU.
Otherwise, the applicant or material supplier, as appropriate, shall provide detailed documentation and test reports in accordance with ISO 6060, showing compliance with this criterion on the basis of monthly averages for the six months preceding the application.

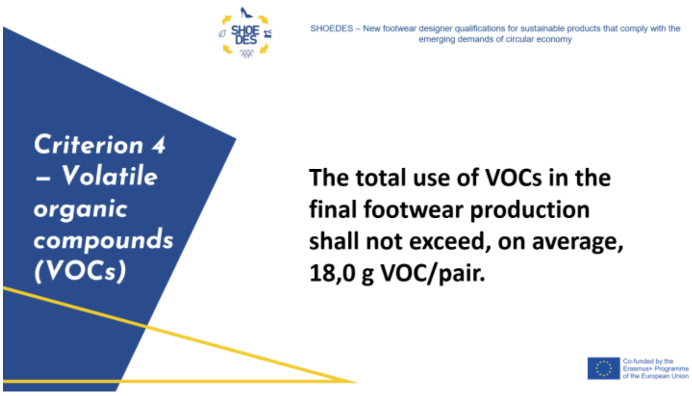
- **The COD value in waste water from the processing of natural or synthetic rubber**, as applicable, when discharged to surface waters after treatment (whether on site or off site), shall not exceed 150,0 mg/l. This requirement shall apply to wet processes used to manufacture the rubber.

Regarding ***Assessment and verification,*** the applicant or material supplier, as appropriate, shall provide a declaration of compliance supported by detailed documentation and test reports, based on ISO 6060 showing compliance with this criterion on the basis of monthly averages for the six months preceding the application.

- The **total chromium concentration in tannery waste water after treatment** shall not exceed 1,0 mg/l as specified in Commission Implementing Decision 2013/84/EU.

As ***Assessment and verification***, the applicant or material supplier, as appropriate, shall provide a declaration of compliance supported by a test report using one of the following test methods: ISO 9174, EN 1233 or EN ISO 11885 for chromium and showing compliance with this criterion on the basis of monthly averages for the six months preceding the application.

Criterion 4 — Volatile organic compounds (VOCs)



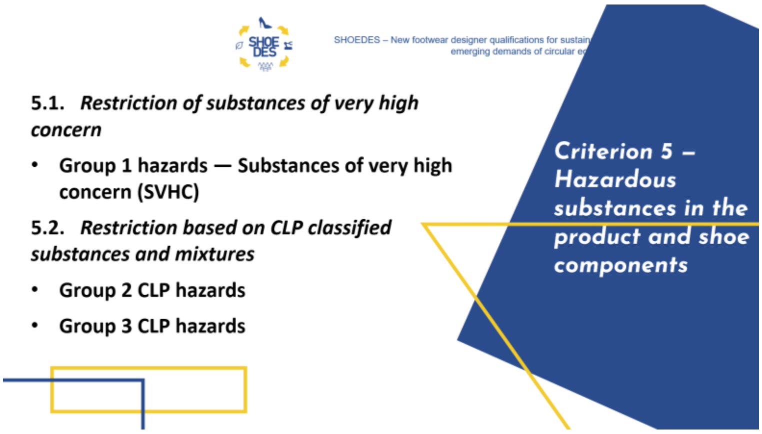
Aside from final footwear, for those classified as personal protective equipment in accordance with Directive 89/686/EEC, the total use of VOCs during final footwear production shall not exceed, on average, 20,0 g VOC/pair.

For ***Assessment and verification,*** the applicant shall provide a declaration of compliance supported by a calculation of the total use of VOCs during final shoe production in accordance with EN 14602. The calculation shall be supported by test results and documentation (registration of purchased leather, adhesives, finishes and production of footwear) as appropriate.

Where applicable, a copy of certification issued by a certification body notified under Directive 89/686/EEC that proves that the product is classified as personal protective equipment shall be provided.

Criterion 5 — Hazardous substances in the product and shoe components

In criteria 5.1. which are **substances for very high concerns**, the final product, and any homogeneous materials or articles thereof, shall not contain substances that have been identified according to the procedure described in Article 59(1) of Regulation (EC) No 1907/2006 and included in the Candidate List for SVHCs in concentrations higher than 0,10 % weight by weight.



No derogation shall be given to Candidate List SVHCs if they are present in the final product, or to any homogeneous materials or articles that form part of the final product in concentrations higher than 0,10 % weight by weight.

For ***Assessment and verification,*** the applicant shall provide a declaration of compliance supported, where appropriate, by declarations from the material supplier regarding the absence of SVHCs at concentrations greater than 0,10 % (weight by weight) for the final product, and any homogeneous materials or articles that form part of the product. Declarations shall be referenced to the latest version of the Candidate List published by ECHA.

For the ***Restriction based on CLP classified substances and mixtures,*** *w*ith the exception of linings and socks, as defined in Article 2(2) of this Decision, the criterion shall apply when the content of any homogeneous material or article in shoe uppers or shoe outer soles is greater than 3,0 % (weight by weight) of either component.

Substances and mixtures groups to which criterion 5.2 shall apply:

- Active substances of biocidal products;
- Dyestuffs (including inks, pigments and varnishes);
- Auxiliary carriers, levelling, blowing and dispersing agents, surfactants;
- Fat liquoring agents;
- Solvents;
- Print thickeners, binders, stabilisers, and plasticisers;
- Flame retardants;
- Cross-linking agents, adhesives;
- Water, dirt, and stain repellents.

Regarding ***Assessment and verification,*** the applicant shall provide a declaration of compliance with criterion 5.2 supported, where appropriate, by declarations from the material supplier(s) including:

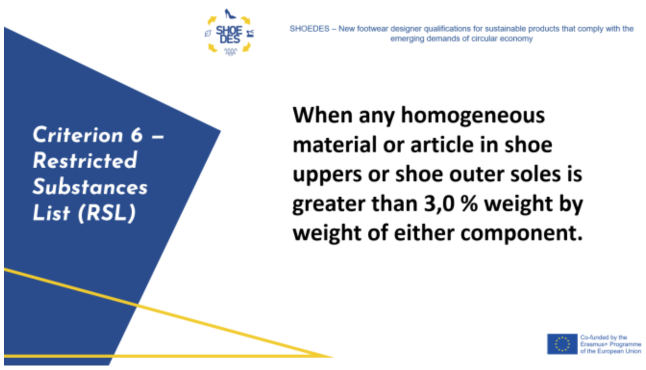
- Toxicological studies and hazard assessments by ECHA peer regulatory agencies, Member State regulatory bodies or intergovernmental bodies.
- A Safety Data Sheet (SDS) fully completed in accordance with Annex II to Regulation (EC) No 1907/2006.
- A documented expert judgement provided by a professional toxicologist. This shall be based on a review of scientific literature and existing testing data, where necessary supported by

results from new testing carried out by independent laboratories using methods recognised by ECHA.

- An attestation, where appropriate based on expert judgement, issued by an accredited conformity assessment body that carries out hazard assessments according to the Globally Harmonised System (GHS) of the classification and labelling of chemicals or CLP hazard classification systems.

Criterion 6 — Restricted Substances List (RSL)

The final product, homogeneous materials or articles that form part of the final product, or production recipes used, as applicable, shall not contain substances specified under the Restricted Substances List (RSL).



For ***Assessment and verification,*** the applicant shall provide a declaration of compliance with the RSL supported by evidence like:

- declarations obtained from those responsible for related production stages;
- declarations from chemical suppliers; or
- test results from laboratory analysis of samples of the final product.

Where laboratory analysis of the final product is required, it shall be performed for specific product lines and based on random sampling. Where specified, it shall be carried out annually during the license period in order to demonstrate ongoing compliance with the RSL criterion with results then communicated to the relevant competent body.

Criterion 7 — Parameters contributing to durability

Occupational and safety footwear shall carry the CE mark and shall meet the durability requirements specified in accordance with Directive 89/686/EEC.

For ***Assessment and verification***, the applicant shall provide a declaration of compliance supported by test reports as specified in the tables below.

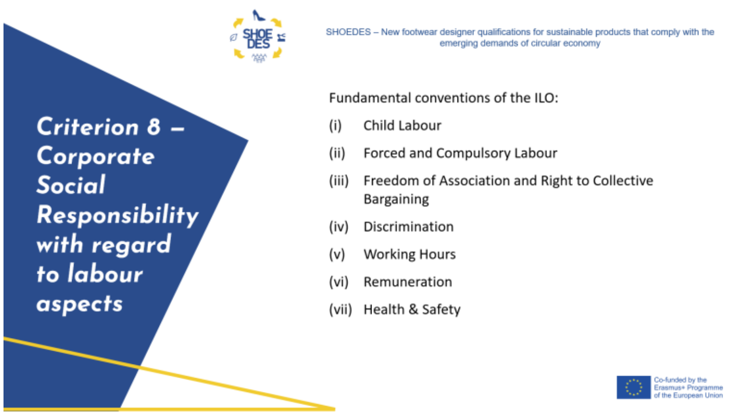
Where applicable, a copy of the certification issued by a certification body notified under Directive 89/686/EEC that proves that the product is classified as personal protective equipment shall be provided.

Durability parameters

Parameter/Standard test method		General sports	School footwear	Casual	Men's town	Cold weather footwear	Women's town	Fashion	Infants	Indoor
Uppers flex resistant: (kc without visible damage)/ EN 13512		Dry = 100 Wet = 20	Dry = 100 Wet = 20	Dry = 80 Wet = 20	Dry = 80 Wet = 20	Dry = 100 Wet = 20 – 20° = 30	Dry = 50 Wet = 10	Dry = 15	Dry = 15	Dry = 15
Uppers tear strength (Average tear force, N)/ EN 13571	Leather Other materials	≥80 ≥40	≥60 ≥40	≥60 ≥40	≥60 ≥40	≥60 ≥40	≥40 ≥40	≥30 ≥30	≥30 ≥30	≥30 ≥30
Outsoles flex resistance: EN 17707	Cut growth (mm) Nsc = no spontaneous crack	≤4 Nsc	≤4 Nsc	≤4 Nsc	≤4 Nsc	≤4 Nsc at – 10 °C	≤4 Nsc			
Outsoles abrasion resistance/ EN 12770	D ≥0,9 g/cm³ (mm³) D < 0,9 g/cm³ (mg)	≤200 ≤150	≤200 ≤150	≤250 ≤170	≤350 ≤200	≤200 ≤150	≤400 ≤250			≤450 ≤300
Upper-sole adhesion (N/mm): EN 17708		≥4,0	≥4,0	≥3,0	≥3,5	≥3,5	≥3,0	≥2,5	≥3,0	≥2,5
Outsoles tear strength (Average strength, N/mm)/ EN 12771	D ≥ 0,9 g/cm³ D < 0,9 g/cm³	8 6	8 6	8 6	6 4	8 6	6 4	5 4	6 5	5 4
Colour fastness of the inside of the footwear (lining or inner face of the upper). Grey scale on the felt after 50 cycles wet/ EN ISO 17700		≥2/3	≥2/3	≥2/3	≥2/3	≥2/3	≥2/3		≥2/3	≥2/3
Linings and socks abrasion cycles/ EN 17704		>25 600 dry >12 800 wet	>25 600 dry >12 800 wet	>25 600 dry >12 800 wet	>25 600 dry >6 400 wet	> 25 600 dry >12 800 wet	>25 600 dry >6 400 wet	>25 600 dry >3 200 wet	>=25 600 dry >=12 800 wet	>8 400 dry >1 600 wet

Criterion 8 — Corporate Social Responsibility with regard to labour aspects

Requirements in this criterion shall apply to the final footwear assembly site. The applicant shall obtain third-party verification supported by site audit(s) that the applicable principles included in the International Labour Organisation's (ILO) fundamental conventions and the supplementary provisions below have been respected at the final footwear assembly site for the product.



The company shall recognise legitimate employee associations with whom it can enter into dialogue about workplace issues.

The audit process shall include consultation with external stakeholders in local areas around sites, including trade unions, community organisations, NGOs and labour experts.

The applicant shall publish the aggregated results and key findings from the audit online in order to provide evidence of their supplier's performance to interested consumers.
In terms of ***Assessment and verification***, the applicant shall provide a declaration of compliance together with copies of certificates and a supporting audit reports for each final product assembly plant for the model(s) to be eco-labelled.
Certificate(s), not dated more than 12 months prior to the application shall be accepted.

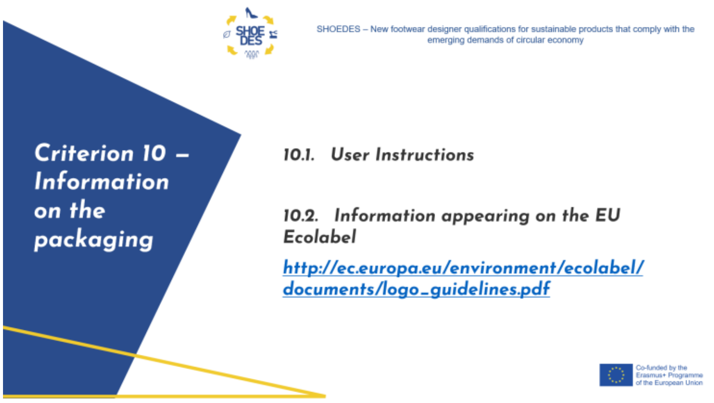
Criterion 9 — Packaging

In terms of packaging requirements, there are two points, first one is cardboard and paper packaging and the other plastic packaging. **Cardboard and paper** used for the final packaging of footwear shall be made of 100 % recycled material. **Plastic** used for the final packaging of footwear shall be made of at least 80 % recycled material.
Regarding ***Assessment and verification***, the applicant or packaging supplier, as appropriate, shall provide a declaration of compliance specifying the material composition of the packaging and the shares of recycled and virgin material.

Criterion 10 — Information on the packaging

The following **information** shall be supplied with the product:

- Cleaning and care instructions specified for each product.
- ‘**Repair your footwear rather than throw it away. This is less damaging to the environment**.’
- ‘**Please dispose of your footwear in the appropriate local collection point**.’



For ***Assessment and verification***, the applicant shall provide a packaging sample or the proposed artwork of the packaging showing the user instructions that will be supplied with the product.
For the criterion 10.2. Information appearing on the EU Ecolabel: the optional label with a text box may be used, which shall contain, where relevant, three of the following statements:

- natural origin raw materials sustainably managed (in case criterion 1 applies);
- reduced pollution in production processes;
- minimized use of hazardous substances;
- tested for durability;
- xx % organic cotton used (this claim may be made only if, based on criterion 1.2(a), more than 95 % of the total cotton is organic).

The guidelines for the use of the optional label with a text box can be found in the ‘Guidelines for use of the Ecolabel logo’ on the website given here.

In terms of ***Assessment and verification**,* the applicant shall provide a declaration of compliance together with a sample of the product label or the proposed artwork showing where the EU Ecolabel is placed.

Quality Certifications for Sustainability and Circular Economy

Up to now, we had discussed the "EU Ecolabel certification criteria on evaluation of suitability of eco-friendly materials from the point of sustainability and circular economy.

Besides EU Ecolabel, there are some other certifications.

One of them is **Cradle to Cradle (C2C) Certification**. It focuses on designing products with materials that can be perpetually cycled. It evaluates products based on criteria such as material health, material reutilization, renewable energy use, water stewardship, and social fairness.

While not solely focused on circular economy principles, **B Corp Certification** evaluates a company's overall social and environmental performance, including efforts towards responsible resource management and waste reduction.

The Ellen MacArthur Foundation promotes circular economy principles and provides guidelines for circular design. While not a certification, adherence to these principles is recognized as a commitment to circularity.

ISO 14001 is a widely recognized standard for environmental management systems. While it doesn't specifically focus on circular economy principles, it encourages organizations to consider environmental aspects in their operations.

Primarily focused on the textile industry, the **Bluesign System** certifies products and processes that are environmentally friendly, economically viable, and socially responsible. It includes criteria related to resource efficiency.

GOTS is a standard for organic textiles that includes criteria related to environmental and social aspects of production. While not exclusively focused on circularity, it promotes responsible and sustainable practices and FSC certification ensures that wood and paper products come from responsibly managed forests, considering environmental, social, and economic aspects. It aligns with circular economy principles by promoting sustainable resource use.

3.3. CONCLUSION

In brief, there are various types of certifications for sustainable materials like B Corp, Cradle to Cradle or Ellen McArthur but in Europe EU Ecolabel is widely known for accreditation of footwear components and materials.

Although EU Ecolabel has various criteria on origin of hides, skins, cotton, wool, cork and man-made fibres, reduction of wastewater, emissions to water resources, VOCs, hazardous substances, packaging and information put on packs, it should have more criteria on circular economic aspects like re-useability, renewability, digital tracking systems based on blockchain, end-of-life considerations, tack-back logistics, social impact etc.

It's important to adapt these controls based on the specific materials used and the intended market for reaching a more sustainable footwear.

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MODULE 3
FOOTWEAR PRODUCT DESIGN FOR CIRCULAR ECONOMY

BY **AURA MIHAI, MARIANA COSTEA, ARINA SEUL** AND **ADRIANA CHIRILA**
GHEORGHE ASACHI TECHNICAL UNIVERSITY OF IASI

Co-funded by
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Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

LECTURE 1
ECO-DESIGN AND CIRCULAR ECONOMY. DESIGN FOR FOOTWEAR END-OF-LIFE: RECYCLING, REUSE AND REPAIR

1.1. INTRODUCTION

In recent years, the landscape of product design has undergone a profound transformation. The traditional role of designers, once primarily focused on meeting functional needs, has shifted towards a new paradigm—one that revolves around stimulating desires and cultivating brand image (Luttropp et al., 2006[9]). Today, it is not merely about addressing utilitarian requirements but also about constructing aspiration and cultivating a sense of identity. In the realm of long-term business perspectives, the creation of market demands often supersedes the mere design and production of products. This complex interplay between consumer desires, environmental sustainability, and economic viability poses a formidable challenge for industries seeking to develop truly sustainable products, particularly in sectors as influential as the global footwear industry.

The increased interest in sustainable product development has sparked the emergence of various tools and guidelines aimed at guiding industries towards eco-consciousness. The following chapters will dive into the key elements and insights the concepts of Eco-Design and Circular Economy, shedding light on the connections between sustainable design principles, environmental considerations, and economic viability. From the depletion of non-renewable resources to the generation of waste and carbon emissions, the footwear industry's impact reverberates across the global environmental landscape. Yet, it is crucial to recognize that within this challenge lies a profound opportunity for transformative change.

Eco-design, as a proactive approach to environmental protection, implies integrating environmental considerations into the product development process. It aims to minimize environmental impacts across the entire lifecycle of a product, without compromising critical criteria such as performance, functionality, aesthetics, quality, and cost (Velenturf et al., 2021[10]). Over the past decades, numerous eco-design methodologies and tools have been developed to evaluate and address environmental impacts, thereby revealing potential issues and facilitating informed choices. However, despite the availability of these tools, their systematic adoption in new product development remains limited (Jacometti, 2019[11]).

[9] Conrad Luttropp, Jessica Lagerstedt, EcoDesign and The Ten Golden Rules: generic advice for merging environmental aspects into product development, Journal of Cleaner Production, Volume 14, Issues 15–16, 2006, Pages 1396-1408, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2005.11.022.

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[11] Jacometti, V. Circular Economy and Waste in the Fashion Industry. *Laws* **2019**, *8*, 27. https://doi.org/10.3390/laws8040027

The footwear industry's journey towards sustainability is deeply intertwined with the principles of the circular economy. Circular economy represents a paradigm shift away from the linear "take, make, dispose" model, seeking to maximize resource use while minimizing waste. In this context, eco-design methodologies serve as essential building blocks, influencing product design, materials selection, production processes, product use, and eventual recycling or repurposing. These methodologies offer a holistic approach to designing products with minimal environmental impact while fostering consumer satisfaction, durability, recyclability, and affordability (Figure 1).

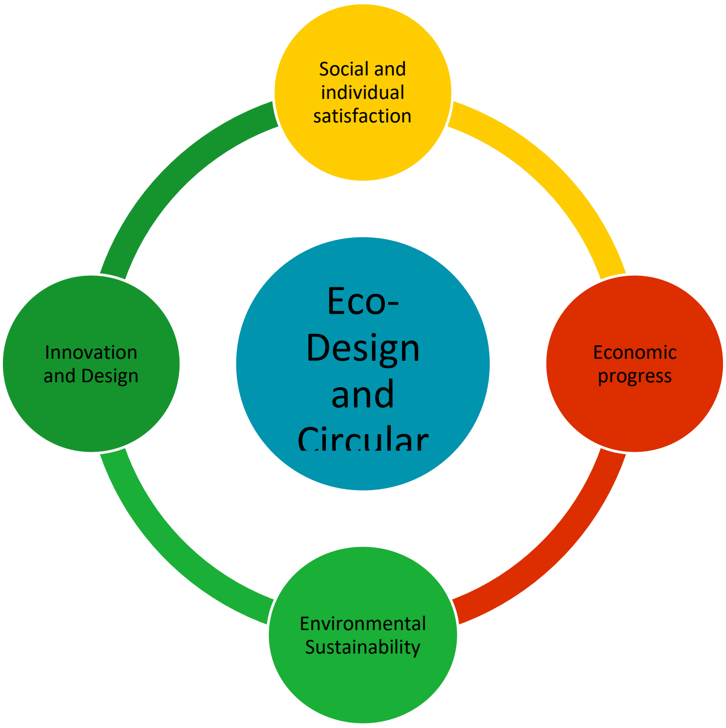

Figure 1. *Eco-Design and Circular Economy, spheres of influence*

This introductory chapter sets the stage for a comprehensive exploration of eco-design and circular economy in the footwear industry. It underscores the critical need for sustainable innovation, not only to address the industry's environmental challenges but also to seize the potential for economic growth through transformative change (Policy Hub, 2019)[12].

[12]Building blocks for a sustainable circular economy for textiles and footwear, POLICY HUB, circularity for apparel and footwear, 2019,
URL: https://assets-global.website-files.com/5dcda718f8a683895d9ea394/5df141c17f7e4e59af1c8eea_Building%20blocks%20for%20a%20sustainable%20circular%20economy%20for%20-%20December%202019.pdf

1.2. UNDERSTANDING THE CONCEPTS

Eco-Design in Footwear

Eco-design within the context of the footwear industry refers to a holistic approach to designing and producing footwear that minimizes its environmental impact throughout its entire life cycle, from material sourcing and manufacturing to product use and end-of-life disposal. It encompasses a set of design principles and practices aimed at reducing resource consumption, minimizing waste, and lowering the carbon footprint associated with footwear production and consumption.

Key aspects of eco-design in the footwear industry are exemplified in Figure 2, and they include the use of sustainable materials and efficient manufacturing processes with a focus on durability and longevity of the products with the end goal of recyclability and disassembly instead of landfill deposits.

Figure 2. *Key aspects of eco-design in the footwear industry*

Eco-designers prioritize the use of sustainable and environmentally friendly materials such as recycled textiles, organic cotton, natural rubber, and leather sourced from responsible and ethical suppliers. These materials are chosen for their lower environmental impact compared to conventional alternatives. They also encourage the adoption of resource-efficient and environmentally responsible manufacturing techniques. This may involve technologies like 3D printing, which reduce material waste, or lean manufacturing principles that optimize production processes. Footwear is designed with a focus on durability and longevity. This includes selecting materials and construction methods that ensure the product lasts longer, reducing the frequency of replacements and, consequently, waste generation.

Eco-designed footwear is constructed with the end of its life cycle in mind. Designers incorporate features that make it easier to disassemble and recycle components or materials, contributing to a circular economy while also exploring options for recycling, repurposing, or upcycling footwear at the end of its usable life. Harmful chemicals and substances are minimized or eliminated from the production process, ensuring that the footwear is safe for wearers and less harmful to the environment during manufacturing and disposal. Brands engaged in eco-design often educate consumers about the environmental impact of their products, encouraging responsible consumption and end-of-life management, such as recycling or donating used footwear.
Overall, eco-design in the footwear industry aligns with broader sustainability goals, aiming to reduce the negative environmental and social impacts associated with the production and consumption of footwear while promoting responsible and eco-conscious choices among consumers and manufacturers.

Core principles of eco-design

Focusing on eco-design and its importance, a series of distinct principles can be determined, such as lifecycle thinking, material selection, energy efficiency, waste reduction, durability and longevity, design for disassembly, user-centered design, innovation and continuous improvement, transparency and communication.

Lifecycle Thinking is based on the perspective that considers a product's entire life cycle, from raw material extraction to manufacturing, distribution, product use, and end-of-life disposal or recycling. This approach to design helps identify environmental hotspots and opportunities for improvement at each stage. Understanding the full life cycle of a product allows designers to make informed decisions that can lead to significant reductions in environmental impact, including reduced resource consumption and waste generation.

Choosing sustainable and environmentally friendly materials is a fundamental eco-design principle. This involves selecting materials with lower environmental footprints, such as recycled, renewable, or responsibly sourced materials. Material selection has a direct impact on a product's carbon footprint, energy use, and resource consumption. Using sustainable materials can reduce the overall environmental impact of a product, connecting itself to the principle of Energy Efficiency. This includes energy-efficient manufacturing processes, reduced energy consumption during product use, and energy recovery or recycling at the end of a product's life. Energy efficiency helps lower greenhouse gas emissions and reduces the product's contribution to climate change. It can also lead to cost savings during manufacturing and use.

Another core principle is minimizing waste generation and promoting recycling and reuse. Reducing waste not only conserves resources but also lowers the environmental impact associated with waste disposal (Figure 3). This can be further supported also by prioritizing durability, robustness, and product longevity in the design phase to extend the time between replacements or upgrades. Longer product lifespans reduce the frequency of production and disposal, conserving resources and reducing overall environmental impact.

Design for Disassembly is yet another principle introduced in the mainstream vocabulary. New products should be designed with ease of disassembly and component separation in mind. This facilitates recycling and repurposing at the end of the product's life. Designing for disassembly makes it more feasible to recover valuable materials and components from discarded products, reducing the need for virgin resources and minimising the environmental impact. Eco-designers aim to minimize the environmental impact of products by considering factors like water use, land use, pollution, and habitat disruption throughout the product's life cycle protecting ecosystems, preserving natural resources, and limiting harm to the planet's biodiversity.

Eco-design takes user needs into account, ensuring that sustainable products are also practical, safe, and enjoyable to use. User education is often part of this principle to promote responsible consumption. Products that meet user needs are more likely to be accepted and used, reducing the overall environmental impact associated with frequent replacements or unused products. In order to achieve this eco-design encourages innovation in materials, processes, and technologies to push the boundaries of sustainability. It also emphasizes ongoing improvement through feedback and monitoring. Continuous improvement drives the development of more sustainable products and processes over time, contributing to a greener future. The consumer can be informed of all the changes performed by this sustainable approach by transparency and clear communication in product information and labelling. Effective communication about a product's eco-friendly attributes is essential for encouraging responsible consumption and it allows consumers to make informed decisions about the products they endorse. Transparency builds trust with consumers, empowers them to make sustainable choices, and encourages companies to uphold their eco-design commitments.

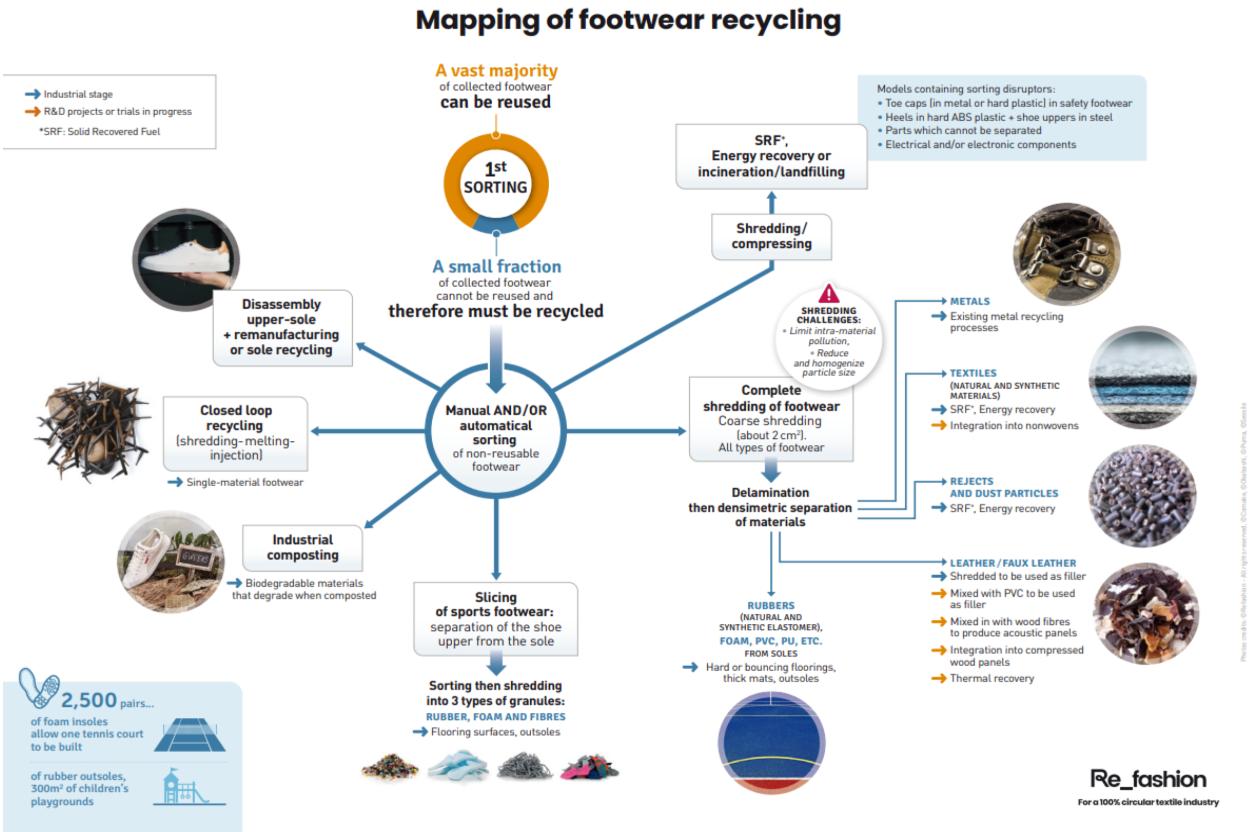

Figure 3. *Mapping of footwear recycling.*
Source: https://refashion.fr/eco-design/sites/default/files/fichiers/Mapping-Footwear-Refashion_EN_3.pdf

Circular Economy in Footwear

The circular economy is a regenerative model where resources are kept in use for as long as possible, and waste and pollution are minimized. Within the footwear industry, this means shifting from the traditional linear approach (make, use, dispose) to a circular one, characterized by:

- Resource Preservation where the emphasis is on preserving resources. Footwear companies seek to reuse, refurbish, remanufacture, and recycle products and materials to extend their lifespan.
- Closed-loop systems that aim to reduce waste by collecting and reusing old shoes and materials. These materials can be used to manufacture new products, reducing the need for virgin resources.

The environmental impacts of footwear production can be significant if unchecked. They include resource depletion because the footwear industry relies on various resources, including leather, rubber, synthetic materials, and metals, and also pollution because footwear manufacturing involves several processes that generate environmental pollutants. Environmental impacts associated with resource depletion are related to leather production, a commonly used material in footwear, which requires significant amounts of water and energy. It often involves the use of chemicals in the tanning process, which can lead to pollution if not managed properly. Rubber and plastic production, particularly synthetic variants, contribute to greenhouse gas emissions and can be challenging to recycle. Many chemicals are used in footwear production, from dyes and adhesives to finishing agents. Improper disposal of these chemicals can result in water and air pollution. Not least, footwear manufacturing generates waste, including off-cuts, defective products, and worn-out tools. Managing this waste is critical to minimize environmental harm.

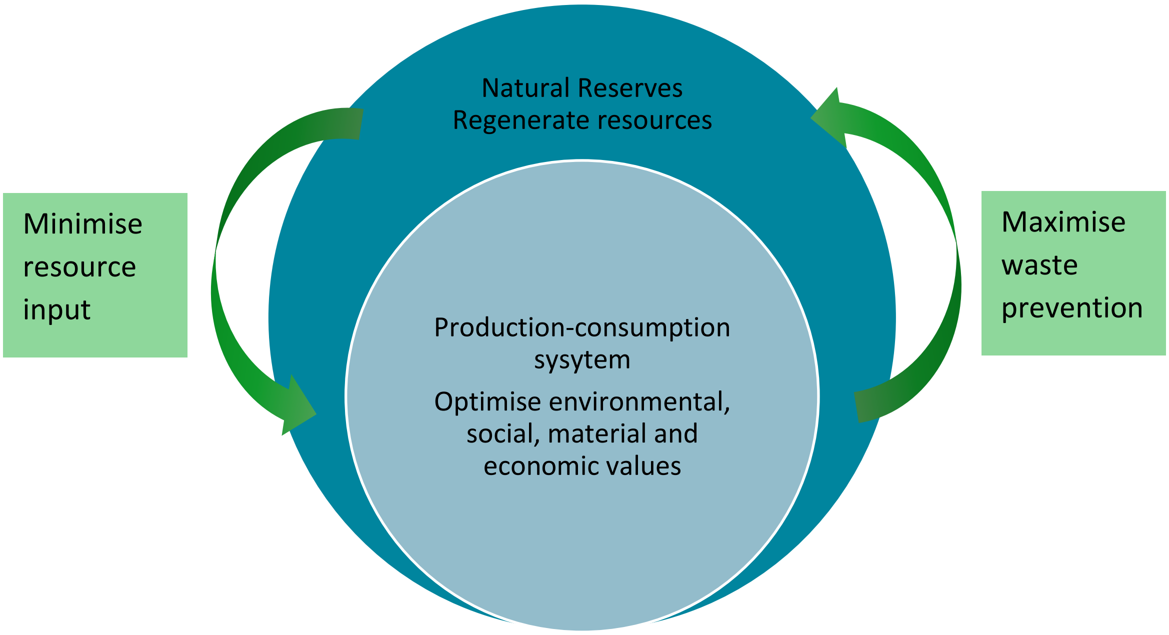

Figure 4. *Circular economy model.*
Source: https://www.sciencedirect.com/science/article/pii/S2352550921000567

The circular economy model aims to shift from the linear approach to one based on resource regeneration and sustainability. It focuses on minimizing waste and maintaining the value of products, materials, and resources within the economy. The core principles of a circular economy are "reduce, reuse, recycle." This means reducing the use of virgin resources, reusing products and materials, and recycling materials to create a closed-loop system. The circular economy seeks to prevent waste generation by designing products that are more durable, repairable, and recyclable. It encourages the repurposing of materials and components. By keeping resources in circulation, a circular economy can reduce environmental impacts, lower energy consumption, decrease greenhouse gas emissions, and create economic opportunities, such as green jobs and sustainable businesses. The primary goal of a circular economy is to achieve long-term sustainability by decoupling economic growth from resource consumption and environmental harm (Velenturf et al., 2021[13]) (Figure 4).

[13] Anne P.M. Velenturf, Phil Purnell, Principles for a sustainable circular economy, Sustainable Production and Consumption, Volume 27, 2021, Pages 1437-1457, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2021.02.018.

Application of circular economy principles

Applying circular economy principles to the footwear industry can significantly reduce waste and enhance resource utilization.

- **Design for Durability and Repairability:** Footwear companies can design shoes to last longer by using high-quality materials and construction techniques and implement modular designs that allow for easy repairs and replacement of individual components like soles, insoles, or laces. Repair services can extend the lifespan of shoes.
- **Reuse and Remanufacturing:** Take-back or buy-back programs where customers can return old shoes in exchange for discounts on new ones have proven successful. Worn-out footwear can be collected and refurbished through cleaning, reconditioning, and resoling for resale. Partnerships with other industries can be explored to repurpose shoe materials for various applications, such as using shoe leather in fashion accessories and used soles as rubber filler.
- **Recycling and Material Recovery:** By investing in advanced recycling technologies to break down old shoes into their constituent materials (e.g., rubber, leather, textiles) materials recovered from old shoes are reintegrated into the production process. Innovative methods for upcycling materials from discarded footwear into new products, such as eco-friendly shoe soles or insoles need to be further explored.
- **Sustainable Materials:** Eco-friendly and sustainable materials for footwear production can be sourced, such as recycled plastics, organic cotton, or bio-based materials. These alternative leather options, such as mushroom leather (mycelium), are encouraged to reduce the environmental impact of traditional leather production. Promote transparency by providing information about the sourcing and environmental impact of materials used.
- **Extended Producer Responsibility (EPR):** Footwear manufacturers can take responsibility for the end-of-life management of their products through EPR programs. Collaboration with industry associations and regulatory bodies to implement EPR initiatives ensures responsible disposal and recycling of footwear.
- **Consumer Education and Engagement:** Educating consumers about the importance of responsible footwear disposal and recycling is part of the circular economy principles. Customers can be encouraged to make sustainable choices by choosing durable, repairable shoes and participating in take-back or recycling programs.
- **Circular Business Models:** Transition to circular business models, such as leasing or subscription services for footwear is considered and alternative part of the circular economy. On a small scale this is already used for occasional sport activities such as bowling and winter sports. However, by exploring partnerships with resale platforms to facilitate the resale of pre-owned shoes the model can be extended.
- **Supply Chain Optimization:** Streamlined supply chains reduce waste, minimize excess inventory, and decrease transportation-related emissions. Implementing just-in-time manufacturing to produce footwear in response to actual demand, reduces overproduction.

- **Collaboration and Innovation:** Collaborating with other industry players, including suppliers, competitors, and recyclers, will create closed-loop systems for footwear materials. And by investing in research and development to identify innovative materials and manufacturing processes further reduces the environmental footprint.
- **Regulatory Compliance:** Stay informed about evolving regulations related to sustainability and waste reduction in the footwear industry. Comply with regulations and certifications that promote sustainable practices and responsible waste management.

By implementing these circular economy principles, the footwear industry can make significant strides toward reducing waste, enhancing resource utilization, and promoting sustainability throughout the product lifecycle, from design and production to disposal and recycling. These efforts not only benefit the environment but also contribute to the industry's long-term resilience and competitiveness.

1.3. METHODS AND TOOLS FOR ECO-DESIGN

Methods and tools for eco-design are essential components of sustainable product development. They help designers and manufacturers integrate environmental considerations into every stage of a product's lifecycle.

Key methods and tools used in eco-design refer to techniques such as:

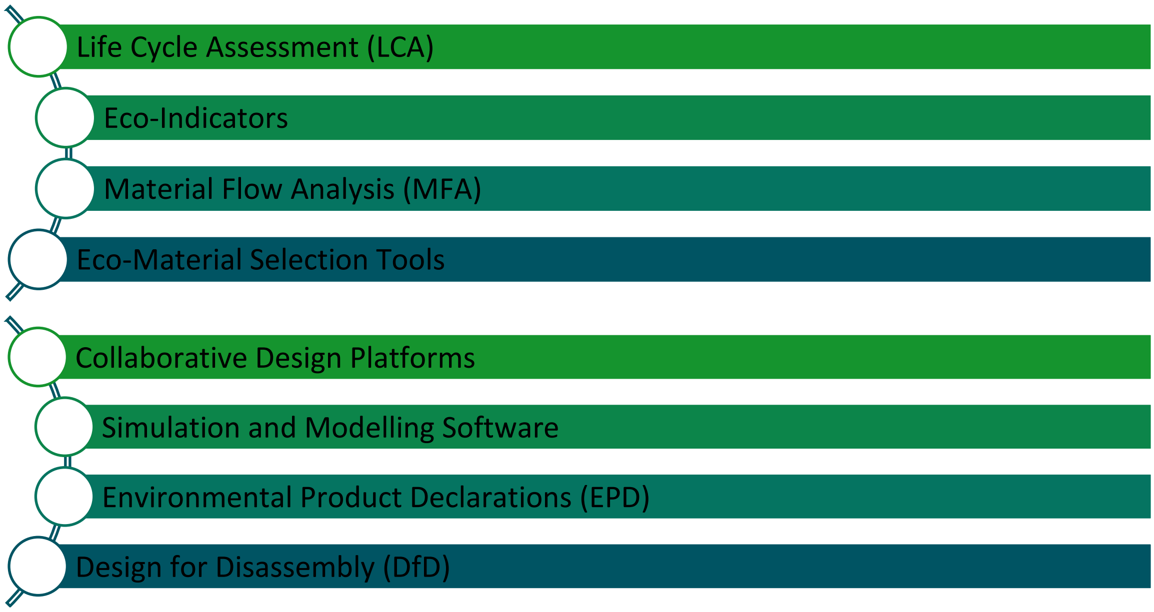

Figure 5*. Key methods and tools used in eco-design*

Life Cycle Assessment (LCA) is a systematic analysis method that evaluates the environmental impacts of a product throughout its entire lifecycle, from raw material extraction to disposal. Designers use LCA to identify environmental "hotspots" in a product's lifecycle, helping them focus on areas where improvements can have the most significant impact. This method can be used to assess the environmental impact of footwear products throughout their entire lifecycle. This includes

evaluating the materials used (e.g., leather, synthetics), manufacturing processes, transportation, use phase, and end-of-life options (e.g., recycling or disposal). Footwear companies can use LCA to identify areas for improvement and make more sustainable design and production choices.
This is a widely spread method commonly used to start the improvement process of a product and footwear companies like Nike (Figure 6), Puma, Adidas, and others, have conducted Life cycle assessments on their articles.

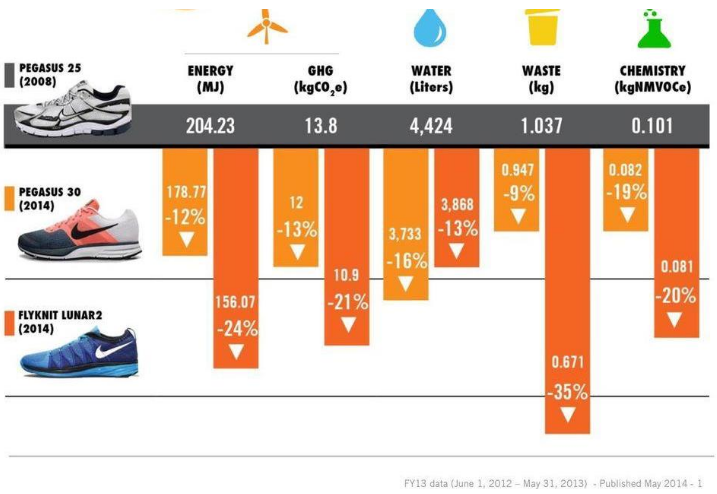

Figure 6. *Nike - Comparative product lifecycle assessment. Source:*
https://www.academia.edu/12167974/Comparative_Analysis_of_Life_Cycle_Assessment_LCA_on_Levis_Jeans_and_Nike_Shoes

Eco-Indicators are metrics and criteria used to assess the environmental performance of products, processes, or materials. Designers use eco-indicators to quantify and compare the environmental impacts of different design options, helping them make informed decisions and minimize a product's environmental footprint.

Material Flow Analysis (MFA) is a method that tracks the flow of materials through various stages of production, use, and disposal. This tool helps identify opportunities for reducing material use, waste generation, and resource consumption in product design and manufacturing. In footwear manufacturing through this method material flows can be tracked and opportunities to reduce waste and resource consumption will be identified. For example, optimizing material cutting patterns to minimize waste or recycling scrap materials in the production process.

Eco-Material Selection Tools are various software tools and databases that provide information on the environmental attributes of materials, including their carbon footprint, toxicity, and recyclability.
Designers use these tools to make informed decisions when selecting materials that align with sustainability goals. Footwear companies can use software tools and databases to assess the

environmental attributes of various shoe materials. This can aid in selecting materials with lower carbon footprints, reduced toxicity, and greater recyclability.

Collaborative Design Platforms are online platforms that enable multidisciplinary teams to collaborate on eco-design projects, share data, and track progress. They are encouraged as a tool to enhance communication and coordination among team members, facilitating eco-design implementation.

Simulation and Modelling Software are generally tools that allow designers to test and optimize various design scenarios virtually, reducing the need for physical prototypes. By simulating different design options, designers can identify energy-efficient and environmentally friendly solutions.
Shoe designers can use simulation tools to optimize shoe designs virtually, reducing the need for physical prototypes. This can lead to more resource-efficient and environmentally friendly shoe designs (figure 7).

Figure 7. *Virtually created shoe design using the 3D software iCAD3D+*

Environmental Product Declarations (EPD) refer to standardized documents that provide transparent information about the environmental performance of a product, based on Life Cycle Assessment data. Environmental Product Declarations help manufacturers communicate the environmental attributes of their products to customers, promoting transparency and informed choices. Often times these manufacturer declarations are mandated as regulatory compliance and certification standards by governmental regulations and industry-specific environmental requirements that products must meet. Compliance with these standards ensures that products adhere to minimum environmental performance criteria, often providing market advantages when they are shared with the customers in the form of eco-labels, as they can demonstrate a commitment to sustainability in the industry.

Design for Disassembly (DfD) focuses on designing products with easy disassembly in mind, allowing for efficient component separation and recycling. Design for disassembly principles enable the recovery of valuable materials from end-of-life products and contribute to circular economy practices. Designing shoes with disassembly in mind can facilitate recycling and the recovery of components and materials. For instance, footwear with modular components that can be easily assembled and disassembled. The sole, insole, upper, and laces can be designed as separate components that can be replaced individually when worn out or damaged. This reduces the need to discard the entire shoe.

These recommendations and best practices can guide designers in making environmentally responsible choices during the design process. Eco-design methods and tools provide practical guidance for integrating sustainability considerations into product development.

These are also human-centered design approaches that involve understanding user needs and preferences to create products that are more likely to be used and retained for longer periods. Designers apply these methods to develop sustainable products that align with user expectations, promoting longer product lifecycles. Understanding consumer preferences and needs is crucial in the footwear industry. Eco-Design thinking with user-centered orientations can help create shoes that are not only environmentally friendly but also appealing and comfortable for consumers while at the same time incorporating circular economy principles to reduce waste by designing shoes for reuse, repair, and recycling.

1.4. CONSUMER BEHAVIOR AND PRODUCT LIFE CYCLE MANAGEMENT

Sustainable consumption by the customers is a pivotal driver in the integration of eco-friendly footwear within the market. As consumers progressively embrace environmental consciousness and social responsibility, their preferences and behaviours have begun to exert a substantial influence on the footwear industry. This influence can be seen and analysed from several points of view.

Firstly, consumers are increasingly expressing a heightened **demand for sustainable footwear products**. They exhibit a strong inclination toward items that align with principles of eco-friendliness, ethical production, and minimal environmental impact. This heightened demand has compelled footwear brands to introduce dedicated sustainable product lines and incorporate environmentally responsible materials into their offerings.

Secondly, the emphasis on **transparency and information**-seeking behaviour among consumers plays a critical role. Consumers today possess a greater awareness of the environmental and ethical practices of footwear brands. They actively seek transparency across various dimensions, including supply chain visibility, production methodologies, and material sourcing. Brands that effectively communicate their sustainability endeavours tend to resonate more strongly with conscientious consumers.

Another facet of this evolving consumer landscape involves a shift in **material preferences**. Consumers are increasingly drawn to sustainable materials for their footwear choices. Materials such as organic cotton, recycled plastics, hemp, and cork have garnered popularity due to their eco-friendly attributes. Brands that successfully integrate these materials into their product designs are better poised to resonate with environmentally conscious consumers.

Furthermore, sustainable consumers place a premium on **durability and longevity** in their footwear selections. They willingly invest in higher-quality shoes that promise extended lifespans and repairability. This inclination prompts brands to reorient their product design processes to prioritize durability, aligning with the consumer demand for long-lasting footwear.
Another significant influence relates to the consumer embrace of **circular economy practices**. Consumers express a growing affinity for brands that offer take-back programs or recycling initiatives, allowing them to return old footwear items for responsible recycling or upcycling into new products.

Ethical labour practices within the footwear industry also feature prominently in consumer concerns. Brands that commit to fair wages, safe working conditions, and ethical labour practices tend to resonate more with socially conscious consumers.
Moreover, consumer behaviour reflects preferences for **locally produced or artisanal footwear**, an option that aligns with sustainability goals by reducing carbon footprints related to transportation and supporting local economies.

Eco-friendly certifications and labels, such as "organic," "vegan," or "Fair Trade," serve as influential factors shaping consumer purchasing decisions. Consumers actively seek out these labels as tangible indicators of sustainable and ethical production practices.

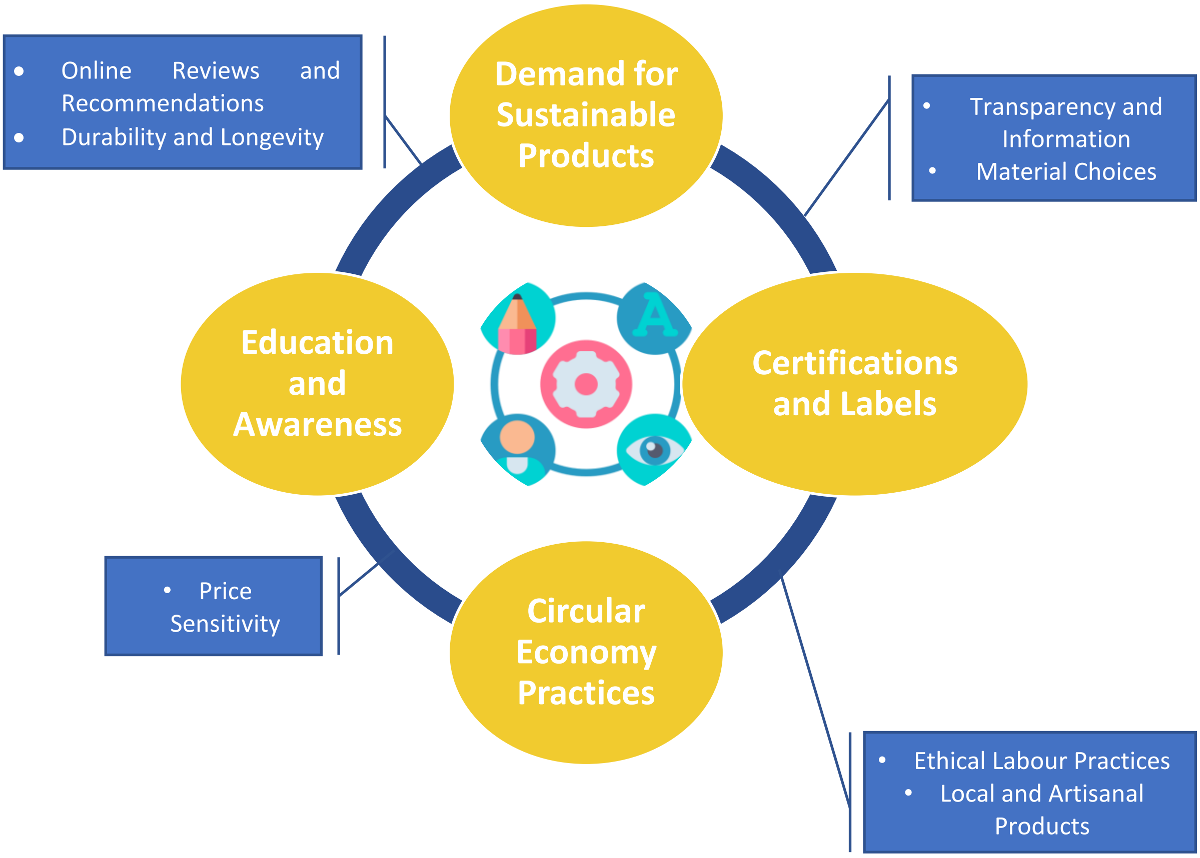

Figure 8. *The influence of consumer behaviour on sustainable footwear choices.*

Consumer reliance on **online reviews and peer recommendations** emerges as a crucial element in guiding sustainable footwear choices. Positive feedback regarding a brand's sustainability efforts can significantly enhance its appeal to potential consumers.

Additionally, **education and awareness** campaigns contribute significantly to shaping consumer behaviour. These campaigns, often led by non-governmental organizations, influencers, and activists, raise awareness about the environmental and social impacts of the footwear industry.

Lastly, **price sensitivity** remains a factor in consumer decisions, even within the sustainable footwear segment. Brands that manage to offer competitively priced sustainable options are likely to attract a broader range of consumers.
Consumer behaviour serves as a driving force behind the availability of sustainable footwear choices. As consumers increasingly prioritize eco-friendliness, ethical considerations, and product durability, footwear brands are adapting their product portfolios and practices to align with these evolving demands. This transition towards sustainability is expected to continue shaping the industry's trajectory in the years to come.

End-of-Life Management: Recycling, Reuse and Repair

End-of-life in footwear design refers to the stage in a product's life cycle where it is no longer in active use and is either discarded, recycled, or repurposed. In the context of footwear, it encompasses the phase when shoes have reached the end of their functional lifespan and are considered to be waste. This stage raises important environmental and sustainability considerations, as footwear disposal can have adverse effects on the environment if not managed responsibly. Footwear designers and manufacturers are increasingly focusing on sustainable end-of-life solutions to minimize the negative impacts associated with discarded shoes, such as landfill waste and resource depletion. These solutions include recycling, reusing, and repairing footwear products to extend their life cycle and reduce the overall environmental footprint of the footwear industry.

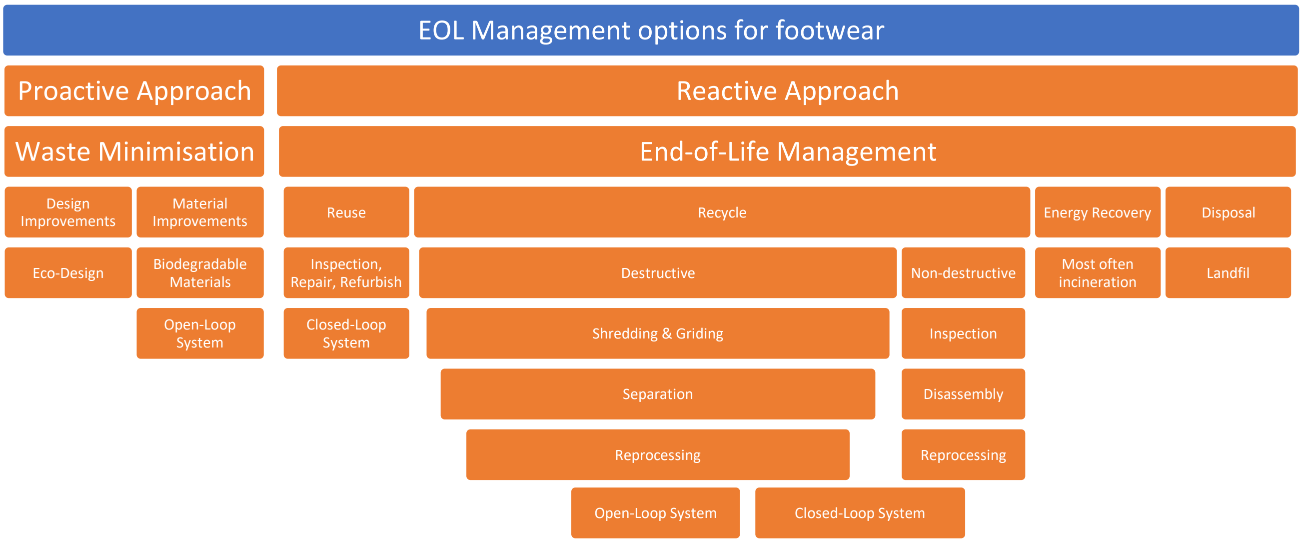

Figure 9. *EOL Management options for footwear*

Recycling Reuse and Repair are sustainable practices that focus on extending the lifespan of footwear products, reducing waste, and minimizing the environmental impact associated with the footwear industry. Recycling in footwear design refers to the process of collecting, disassembling, and reusing materials from old or worn-out footwear products to create new footwear or other products. This approach aims to reduce waste, conserve resources, and minimize the environmental impact associated with footwear disposal. Recycling in footwear design involves various methods and practices, such as material reclamation, sole regrinding, upcycling, closed-loop systems, and the use of recycled materials like PET (polyethylene terephthalate) and EVA (ethylene-vinyl acetate) foam. Some footwear brands are exploring closed-loop systems, where they take back worn-out shoes from consumers and use the materials to produce new shoes. This approach helps maintain control over material sourcing and ensures that materials are reused efficiently. By incorporating recycling principles into the design and production of footwear, brands and manufacturers contribute to a more sustainable and environmentally responsible industry.

Figure 10. *Recycle, Reuse and Repair footwear*

Reuse involves the act of using a footwear product again after it has been previously worn or used. This can take several forms, such as second-hand sales, shoe rental or exchange programs.
Footwear that is still in good condition can be resold or donated to second-hand stores, charity organizations, or online marketplaces. Consumers can purchase gently used shoes at a lower cost than new ones. Additionally, some businesses offer shoe rental services for special occasions or activities, allowing customers to temporarily use high-quality footwear without needing to purchase them. A new trend in footwear has brands or retailers implementing programs that encourage customers to exchange their old shoes for discounts on new ones, promoting the reuse of footwear.
Finally Repair involves the maintenance and refurbishment of footwear to ensure its continued functionality and usability. Repairing footwear instead of discarding it helps reduce the need for new products and conserves resources. Repair activities may include sole replacement where worn-out soles are replaced with new ones, extending the life of the footwear, or stitching and patching tears, holes, or loose seams and also cleaning and refurbishing which can refresh the appearance of footwear and address minor damage or reconditioning some footwear to restore their original quality.
These practices contribute to a more sustainable and circular approach to footwear design and consumption by reducing waste and promoting the longevity of products.

LECTURE 2
CONSTRAINTS AND SPECIFICATIONS FOR SUSTAINABLE DESIGN. MASS CUSTOMISATION AND CIRCULAR ECONOMY

2.1. INTRODUCTION

Sustainability has become a cornerstone of innovation and progress across industries worldwide. In the footwear industry, this concept transitioned towards eco-conscious design principles, mass customization, and circular economy practices. As consumers increasingly demand footwear that aligns with environmental and ethical values, the industry finds itself navigating a complex terrain defined by constraints and specifications that harmonize sustainable design, personalization, and circularity.

Sustainable design, often regarded as the foundation for innovation in the industry, underscores the imperative to create footwear that minimizes its environmental footprint, supports ethical labour practices, and optimizes product life cycles. This approach involves meticulous attention to constraints and specifications that extend across the entire product lifecycle. Materials selection, eco-friendly manufacturing processes, durability, transparency, and certifications have become pivotal considerations for brands aspiring to craft sustainable footwear that resonates with an environmentally conscious consumer base.

Simultaneously, the need of mass customization has initiated a new range of personalized consumer experiences. Footwear brands are now tasked with accommodating individual preferences and needs (fig. 1), prompting a fresh set of constraints and specifications. Advanced technologies like 3D scanning and user-friendly interfaces become indispensable, while data privacy and quality control emerge as critical specifications. Moreover, adapting supply chains to efficiently deliver customized products becomes an intricate challenge to surmount.

Figure 11. *Example of Customised Footwear. Source: https://julianshoes.ro/*

Complementing this movement towards personalization is the circular economy, an approach that seeks to redefine the traditional linear model of "take, make, dispose" by emphasizing resource efficiency, recycling, and reusability. Circular practices in the footwear industry impose the ideas like take-back systems, material circularity, design for disassembly, and robust consumer engagement strategies.

This module debates the intricate constraints and specifications that guide sustainable design approaches, mass customization, and circular economy initiatives within the footwear industry. It explores the multitude of challenges and opportunities presented by these evolving concepts, shedding light on how brands can navigate this transformative landscape to answer to the demands of an environmentally conscious consumer base.

A. Sustainable design principles

Sustainable design principles, often referred to as eco-design or green design principles, are a set of guidelines and strategies aimed at creating products, systems, and environments that minimize negative impacts on the environment, promote social responsibility, and prioritize long-term economic viability. These principles are essential for addressing pressing global challenges such as climate change, resource depletion, and social inequality. Key sustainable design principles (fig. 2) include **Life Cycle Thinking**, which considers the entire life cycle of a product, system, or building. This includes the extraction of raw materials, manufacturing, transportation, use, maintenance, and end-of-life disposal or recycling. By analysing each phase, designers can identify opportunities to reduce environmental and social impacts.

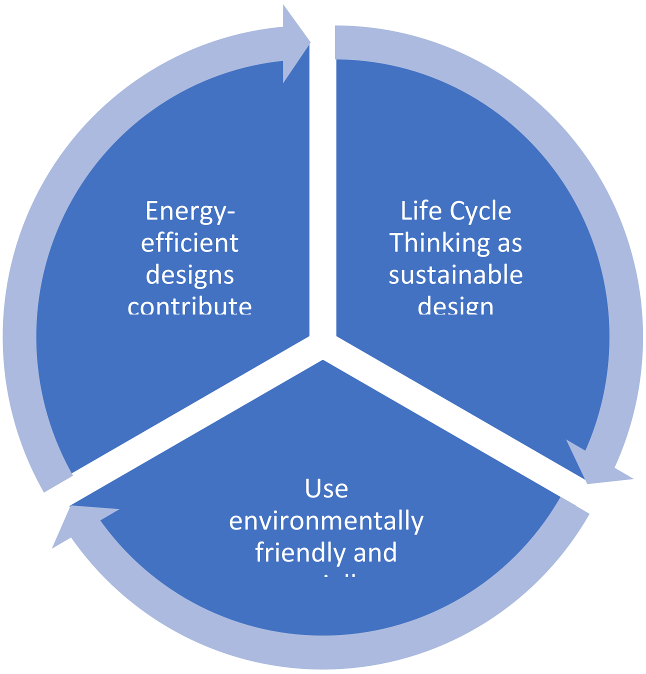

Figure 12. *Core sustainable design principles*

Sustainable design emphasizes the use of **environmentally friendly and socially responsible materials**. This includes choosing materials with lower carbon footprints, reduced toxicity, and those that are recyclable or biodegradable. It also involves sourcing materials from suppliers with ethical practices that aim to minimize energy consumption throughout a product's life cycle. Another understanding of this principle is designing products that require less energy to manufacture, operate, and maintain. **Energy-efficient designs** contribute to lower greenhouse gas emissions and reduced operating costs.

Waste Reduction is a critical aspect of sustainable design, this includes designing products to generate less waste during production, promoting reuse and recycling, and considering how products can be disassembled and recycled at the end of their life. The product life span for sustainable products is already longer than standard articles of the industry because durable designs contribute to resource conservation and lower overall environmental impact reducing the frequency of replacement. Design footwear with disassembly in mind involves designing products in a manner that facilitates the separation of components and materials for repair, reuse, or recycling, extending the product's life cycle and approaching design through minimalism and simplicity. This often follows the principle of "less is more," aiming to simplify designs, reduce unnecessary features and materials, which can lead to reduced resource consumption and waste generation.

Another approach of this concept is **Cradle-to-Cradle (C2C) Design** which envisions products as materials that can be perpetually recycled or upcycled, eliminating the concept of waste. It encourages the creation of closed-loop systems where products are designed to be endlessly reusable.

Sustainable design promotes the use of renewable energy sources, such as solar and wind power. It also encourages the utilization of renewable materials like bamboo or sustainably harvested wood, often times acquired from local sources. Reducing transportation distances by sourcing materials locally and promoting local manufacturing can lower carbon emissions associated with shipping and contribute to the local economy.

Sustainable design considers the needs and behaviours of users. User-centered design leads to products that are more functional, efficient, and likely to be embraced by consumers leading to transparency in the supply chain, ensuring that products are made under ethical conditions and that consumers have access to information about a product's environmental and social impacts.
In summary, sustainable design principles are not only relevant but also essential for the footwear industry to address environmental, social, and economic challenges. They offers opportunities for innovation, cost savings, market growth, and risk reduction while aligning with the values and expectations of consumers and regulators.

2.2. METHODS IN SUSTAINABLE FOOTWEAR DESIGN

Research and Analysis

Research and analysis are foundational in the realm of sustainable footwear design, guiding designers and companies towards environmentally friendly and socially responsible products. Key aspects of this process include material selection, life cycle assessment (LCA), supply chain analysis, design for disassembly, consumer behaviours research, regulatory compliance, material sourcing, carbon footprint analysis, prototype testing, cost-benefit analysis, collaborative research, feedback loops, circular economy considerations, social impact assessment, ethical sourcing, and studying successful case studies. These activities facilitate informed decision-making, aiming to reduce environmental and social impacts while fostering innovation in eco-friendly footwear products (fig. 3, fig. 4).

Material Selection & Sourcing

Supply Chain Analysis

Consumer Behaviour Research

Carbon Footprint Analysis

Life Cycle Assessment (LCA)

Figure 13. Methods included in the Research and analysis toolkit. Part 1

Material Selection is the bedrock of sustainable design lies in the astute choice of materials. Designers must embark on a quest to unearth eco-friendly alternatives to the conventional materials that have historically dominated the footwear landscape, such as leather, synthetic plastics, and rubber. This pursuit demands a meticulous assessment of each material's environmental footprint, durability, and performance characteristics, ushering in the era of organic cotton, recycled PET, Tencel, Piñatex (crafted from pineapple fibers), and bio-based synthetics. The quest for sustainable materials necessitates a pilgrimage into the realm of suppliers, certifications (GOTS for organic textiles, FSC for sustainable wood), and the environmental toll extracted during material acquisition or cultivation.

Supply Chain Analysis is a method that provokes the designer to scrutinize the intricate threads of the supply chain. This is more of a voyage into the heart of the supply chain, assessing the sustainability practices of suppliers and manufacturers. This audit encompasses an evaluation of labour conditions, waste management strategies, and energy consumption patterns.

Consumer Behaviour Research is another method where understanding the intricate consumer preferences and behaviours, especially those around sustainable footwear, stands as mandatory. The research apparatus, including surveys, focus groups, and market research, becomes the guide in illuminating the path towards fulfilling the aspirations of eco-conscious consumers.

Carbon Footprint Analysis servers as a magnifying glass on carbon emissions. The analysis methodically dissects the carbon emissions intertwined with the production, transportation, and usage of footwear products, illuminating a path towards reducing this environmental footprint through responsible design choices and optimization of supply chains.

Life Cycle Assessment (LCA), a crucial instrument in the designer's toolkit, LCA shows a panoramic canvas that scrutinizes the environmental impact of a product across its entire life cycle. From the initial extraction of raw materials to the eventual disposal, LCA guides designers in deciphering which phases carry the most profound environmental consequences and pinpointing avenues for refinement and enhancement.

Design for Disassembly (DfD)

Prototype Testing

Cost-Benefit Analysis

Feedback Loops

Social Impact Assessment

Figure 14. Methods included in the Research and analysis toolkit. Part 2

Design for Disassembly (DfD) is the sentinel that guards the gates of circular design. It is the conscious act of designing products with an innate propensity for facile disassembly, simplifying the act of parting ways with materials at the end of a product's life. The profound analysis of Design for Disassembly’s feasibility stands at the beginning of every circular product model.

Prototype Testing is essential when sustainable footwear designs are tested and refined in the conditions of the real world. Factors such as comfort, durability, and performance are subjected to rigorous scrutiny, ensuring that the final product aligns seamlessly with user expectations.

Cost-Benefit Analysis takes into account the financial implications of sustainable design choices, which occasionally carry higher upfront costs. Through meticulous cost-benefit analyses, designers can discern the value of eco-friendly materials and practices in contrast to their conventional counterparts.

Feedback Loops engages designers, consumers, suppliers, and manufacturers, and at the end sustainable design strategies are honed to perfection, fostering continuous enhancements. Collaboration with professionals in sustainability, materials science, and environmental impact helps in the process of evaluation and it ensures that research and analysis feedbacks are included in improvement endeavours. At this point the lessons of successful sustainable footwear can offer a source of wisdom and best practices. Case studies are tools from which valuable insights and effective design strategies are distilled.

Social Impact Assessment embraces the intricacies of social impact, including labour conditions and worker well-being, beyond the ecological standpoint. Designers and researchers must stand vigilant, ensuring their creations adhere rigorously to legal mandates governing materials, manufacturing processes, and worker safety practices.

In summation, research and analysis in sustainable footwear design stand as a multitude of activities, from the discerning selection of materials to the panoramic evaluation of life cycles, from the scrutiny of supply chains to the meticulous study of consumer inclinations. These activities are the compass guiding informed decisions, effecting a reduction in environmental and social footprints, and weaving innovative, eco-friendly footwear products into the fabric of our world.

Additionally, market research is vital for understanding consumer preferences, target audiences, competitive landscapes, trends, regulations, market size, pricing, distribution channels, brand reputation, marketing strategies, consumer education, product life cycles, sustainability certifications, distribution networks, and feedback mechanisms, all of which enable businesses to cater to the demands of eco-conscious consumers.

Inspiration and Concept Development

Generating ideas and concept development are pivotal stages in sustainable footwear design, guiding the transition from creative ideas to actionable concepts aligned with sustainability principles. A systematic approach involves research, setting sustainability goals, brainstorming, mood boards, sketching, prototyping, material selection, functionality, design for disassembly (DfD), collaboration, feedback, sustainability assessment, iteration, final concept selection, detailing, prototype testing, presentation, and documentation. This comprehensive process ensures that sustainable footwear designs are both environmentally responsible and attractive to consumers who value style and responsibility. Generating sustainable design concepts for footwear demands a creative and eco-conscious mindset (fig. 5). This process begins with problem identification within the footwear industry, defining a sustainability brief, and drawing inspiration from nature (biomimicry). Embracing the circular economy, exploring sustainable materials, favouring local sourcing, aiming for zero waste, modular design, sustainable dyes and finishes, cultural and ethical influences, repairability, transparency, functionality, user-centered design, collaboration, life cycle assessment (LCA), trend forecasting, cross-disciplinary insights, prototyping, feedback, and iterative design are all essential considerations. Integrating these techniques and factors enables the development of innovative and sustainable footwear concepts that address environmental and social challenges while meeting user expectations.

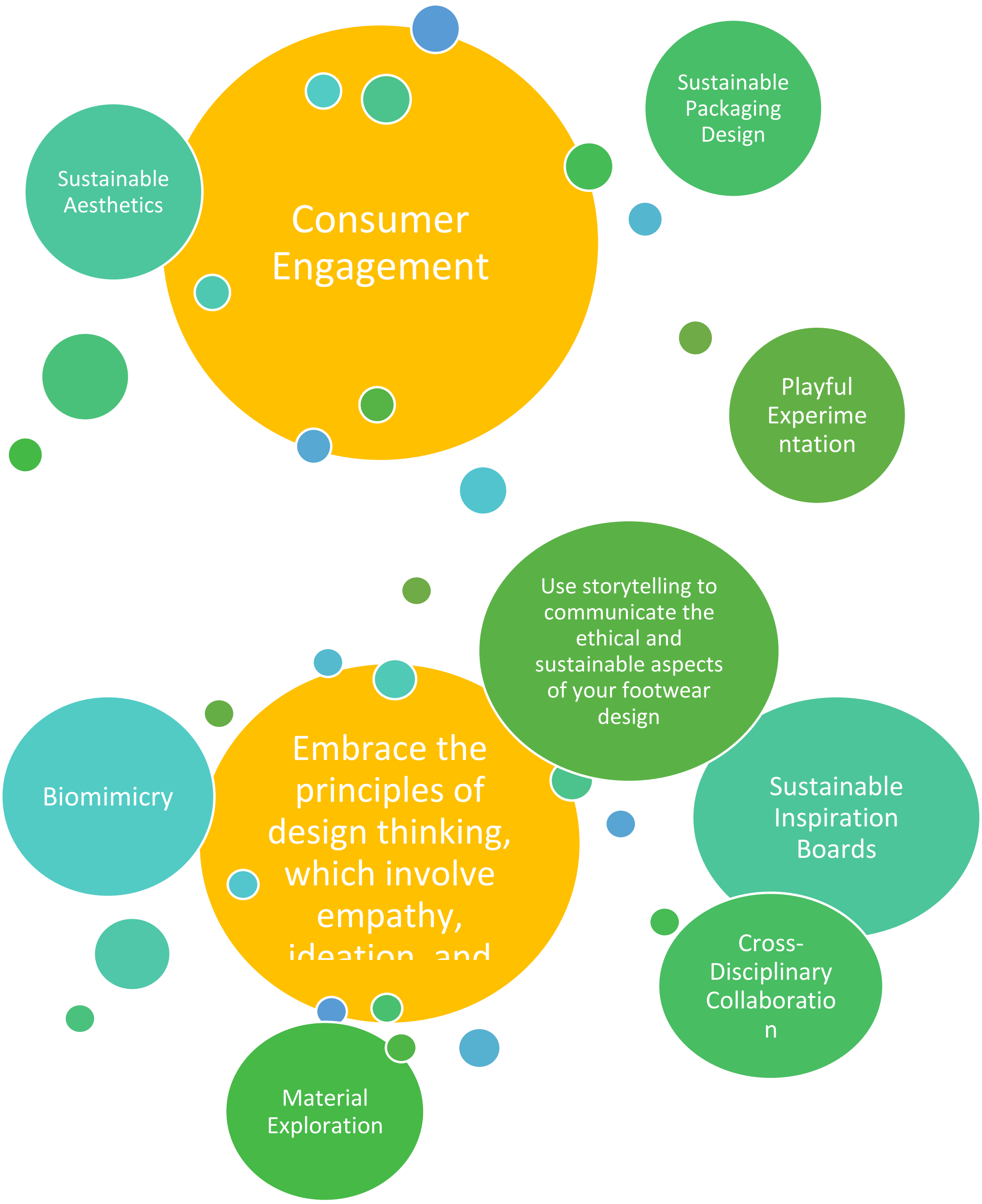

Figure 15. *Creativity in sustainable design*

Fostering creativity in sustainable footwear design is a learned skill, paramount for developing innovative and environmentally responsible products. Several key principles and strategies can guide this creative process:

- Design thinking, centered on empathy, ideation, and iteration, should be the foundation. Understanding the needs and preferences of consumers seeking sustainable footwear is crucial.

- Nature's designs and processes offer inspiration. Biomimicry encourages mimicking nature's efficiency and sustainability in footwear design.
- Create inspiration boards focused on sustainability, gathering images, materials, and concepts reflecting eco-friendly design elements.
- Collaborate with experts from diverse fields, such as materials science, environmental science, and fashion, to bring varied perspectives and ideas to the design process.
- Experiment with unconventional, sustainable materials like mushroom leather, algae-based textiles, or recycled plastics to inspire new design possibilities.
- Adopt a circular design approach, considering longevity, repairability, and recyclability. Concepts like modular footwear and upcycling should be explored.
- Use storytelling to communicate the ethical and sustainable aspects of your footwear design, connecting with consumers by sharing the journey and values behind your products.
- Experiment with eco-friendly colour options, such as natural dyes or low-impact pigments, for unique and sustainable colourways.
- Embrace minimalist design principles focusing on simplicity, functionality, and reduced material usage, resulting in elegant and sustainable footwear.
- Draw inspiration from cultures and traditions emphasizing sustainable practices in footwear design, exploring traditional craftsmanship and materials.
- Develop a signature aesthetic incorporating sustainable elements to make your footwear recognizable as eco-conscious.
- Explore opportunities to creatively upcycle or repurpose existing materials or footwear components, leading to unique and sustainable design solutions.
- Experiment with combinations of sustainable materials for visually appealing and functional designs, such as mixing organic textiles with recycled rubber.
- Incorporate eco-friendly embellishments like reclaimed buttons, vintage buckles, or recycled jewellery to add character to your designs.
- Involve consumers in the design process through crowdsourcing or co-creation initiatives, as their input can lead to fresh and sustainable ideas.
- Participate in sustainability design challenges and competitions to push the boundaries of eco-friendly footwear design.
- Analyse existing footwear products and reverse engineer them with a sustainability focus, identifying areas for improvement and innovation.
- Stay informed about emerging sustainable footwear trends and incorporate them into your creative process.
- Extend sustainability to packaging with eco-friendly, reusable, or minimal solutions that align with your footwear brand.
- Encourage a culture of playful experimentation within your design team, fostering creativity where ideas can be explored without constraints.

Design Prototyping and Testing

Design prototyping and testing are pivotal phases in the development of sustainable footwear. They involve creating prototypes, assessing materials and construction, and ensuring that the final product meets sustainability objectives. This process begins with prototype development, which can employ 3D printing for rapid iterations or traditional methods using sustainable materials.

Sustainable material selection, functionality testing, durability assessments, and comfort and fit evaluations are integral steps. Sustainability metrics and material efficiency, recyclability, and user feedback play essential roles. The assessment extends to manufacturing processes, cost analysis, compliance with standards, and effective communication of sustainability attributes. Preparing for production scaling, stakeholder engagement, and a commitment to continuous improvement complete this rigorous process. Ultimately, these steps ensure that sustainable footwear not only aligns with environmental goals but also delivers on functionality, comfort, and economic viability, contributing to a responsible and sustainable footwear industry.

2.3. CONSTRAINTS IN SUSTAINABLE FOOTWEAR DESIGN

Constraints play a vital role in sustainable footwear design. They help designers make informed decisions, set boundaries, and ensure that sustainability goals are met (fig. 6).

Figure 16. *Key approaches in sustainable footwear design*

Design for Additive Manufacturing (DfAM) in footwear is a specialized design approach that harnesses the unique advantages of additive manufacturing, often referred to as 3D printing, to create innovative and highly customized footwear products. This approach prioritizes the seamless integration of technology into the design process, allowing for the creation of shoes that are not only tailored to an individual's precise foot measurements and preferences but also optimized for performance and sustainability. DfAM in footwear entails designing intricate and complex geometries that are difficult or impossible to achieve using traditional manufacturing methods, such as lattice structures for cushioning and lightweighting. It also emphasizes considerations for materials selection, ease of assembly and disassembly for repair and recycling, and cost-effectiveness. Ultimately, DfAM revolutionizes footwear design by offering a pathway to more personalized, sustainable, and technologically advanced shoe products.

Design for Assembly (DfA) is a systematic approach to product design that focuses on simplifying the assembly process and minimizing the number of components required for a product's construction. In the context of footwear design, DfA aims to create shoes that can be efficiently and cost-effectively assembled during manufacturing. This involves designing shoe components and features in a way that reduces the complexity of assembly, eliminates the need for specialized tools or excessive manual labor, and streamlines the production process. DfA in footwear can lead to benefits such as shorter production times, reduced manufacturing costs, and improved product quality, making it an essential consideration for designing shoes that are not only functional and stylish but also efficient to produce.

Design for Disassembly (DfD) is an engineering and design principle that focuses on creating products in a way that makes them easy to take apart or disassemble when they reach the end of their lifecycle. In the context of footwear, DfD means designing shoes with the intention of simplifying the process of breaking them down into their individual components or materials for repair, recycling, or reuse. This approach encourages sustainability by enabling the efficient recovery of valuable materials and components from old or worn-out shoes, reducing waste and environmental impact. Designing shoes with DfD in mind involves using fasteners, adhesives, or modular components that can be easily separated, and it contributes to the broader goal of achieving a circular economy in the footwear industry, where resources are conserved and reused to minimize waste.
To provide design solutions for these crucial design approaches the bellow constrains must be considered.

Regulatory and Compliance Constraints

In Europe, sustainable footwear design and production are subject to various regulatory and compliance constraints (fig. 7). These constraints ensure that footwear products meet stringent environmental and labour standards while complying with legal requirements in different regions. Additionally, certifications and eco-labels play a significant role in demonstrating a product's sustainability.

Compliance with Environmental Standards
The European Union's REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) regulation restricts the use of hazardous chemicals in footwear materials and production processes. Sustainable footwear must comply with REACH restrictions to ensure the safety of consumers and the environment.

ISO 14001 is an international standard for environmental management systems. Sustainable footwear manufacturers may seek ISO 14001 certification to demonstrate their commitment to environmental responsibility and compliance with environmental standards.

Compliance with Labor Standards

Sustainable footwear production in Europe must adhere to the labour laws and regulations of the European Union. This includes ensuring fair wages, safe working conditions, and compliance with EU directives on workers' rights.

Some footwear brands opt for Fair Trade certification to guarantee that workers involved in the production process are compensated fairly and work in ethical conditions.

Legal Constraints in Different European Regions

European countries may have specific product safety regulations that impact footwear design and manufacturing. Compliance with these regulations is essential to ensure that footwear products are safe for consumers.

Footwear sold in the European Union must comply with labelling requirements. Labels should provide information about material composition, care instructions, and any eco-labels or certifications. This ensures transparency and helps consumers make informed choices.

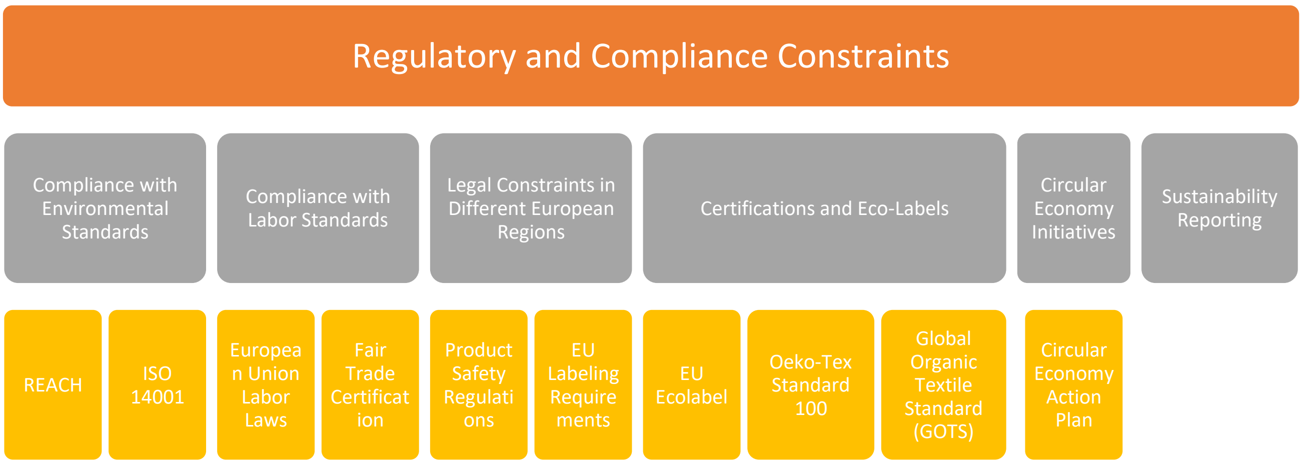

Figure 17. *Regulatory and Compliance Constraints*

Certifications and Eco-Labels

The EU Ecolabel is a well-recognized eco-label in Europe. Sustainable footwear products bearing the EU Ecolabel have met strict environmental and performance criteria. This label assures consumers that the product has a reduced environmental impact.

While Oeko-Tex is an international certification, many European footwear brands and manufacturers seek Oeko-Tex Standard 100 certification, which certifies that footwear components and materials are free from harmful substances.

Global Organic Textile Standard (GOTS) certification is relevant for sustainable footwear made from organic textiles. It ensures that the materials used meet organic and environmental criteria.

Circular Economy Initiatives

Europe is actively promoting the circular economy, which includes initiatives like the Circular Economy Action Plan. Sustainable footwear brands are encouraged to participate in circular economy efforts by designing products that are durable, repairable, and recyclable.

Sustainability Reporting

In some European countries, larger companies are required to disclose sustainability-related information in their annual reports. Sustainable footwear brands may need to report on their environmental and social practices.

Cost and Resource Constraints

Figure 18. *Cost and Resource Constraints*

Balancing Sustainability with Production Costs

Sustainable footwear brands in Europe often face the challenge of balancing sustainability goals with production costs. For instance, using recycled or organic materials can be more expensive than traditional materials. Brands need to carefully assess the cost implications of sustainable choices and find cost-effective solutions.

Sourcing Sustainable Materials Cost-Effectively

Sustainable footwear brands may prioritize using eco-friendly and ethically sourced materials. However, these materials can sometimes be costlier due to their limited availability or specialized production processes. For instance, sourcing sustainable leather or alternative materials like mushroom leather might be more expensive compared to conventional leather. Brands need to explore supply chain efficiencies and partnerships to mitigate these cost challenges.

Resource Limitations in Sustainable Design

Sustainable design principles often emphasize durability and longevity to reduce waste. However, this can lead to resource constraints, as the footwear industry may require access to certain materials that are in limited supply. Brands must explore alternative materials or innovative production techniques to address these limitations. For example, they may experiment with bio-based materials or recycled fibers to reduce resource dependency.

Eco-Friendly Production Technologies

Implementing eco-friendly production technologies, such as waterless dyeing or 3D knitting, can require significant investments in new equipment and processes. While these technologies offer sustainability benefits, they may initially increase production costs. Brands need to assess the long-term cost savings and environmental benefits of adopting such technologies.

Consumer Price Expectations

Consumers may have specific price expectations for footwear. Sustainable footwear brands may need to educate consumers about the value of sustainable products and justify higher price points. Effective marketing and storytelling can help consumers understand the environmental and social benefits associated with sustainable footwear.

Circular Economy Transition Costs

Transitioning to a circular economy model, where footwear is designed for durability and recyclability, may require significant investments in research, design, and production. Brands need to consider these upfront costs and plan for them strategically to ensure long-term sustainability.

Regulatory Compliance Costs

Ensuring compliance with stringent environmental and labour regulations in Europe may require investments in monitoring, reporting, and audits. Brands need to allocate resources to meet these compliance requirements while maintaining sustainable practices.

Supply Chain Transparency Costs

Achieving transparency in the supply chain, which is essential for sustainability, may involve costs related to traceability systems and audits of suppliers. Brands must budget for these transparency-related expenses. Sustainable footwear brands must navigate these cost and resource constraints creatively and strategically. While there may be upfront challenges, investing in sustainable practices can lead to long-term benefits, including enhanced brand reputation, consumer loyalty, and reduced environmental impact.

Consumer and Market Constraints

Figure 19. *Consumer and Market Constraints*

Consumer Awareness and Education

Many consumers in Europe may not be fully aware of the environmental and social impacts of footwear production. Sustainable footwear brands often face the challenge of educating consumers about the benefits of sustainable choices. This can involve marketing campaigns, transparency initiatives, and collaborations with environmental organizations to raise awareness.

Price Sensitivity

Consumers may be price-sensitive when it comes to footwear purchases. Sustainable footwear brands often face the constraint of competing with lower-priced conventional footwear. Brands must find ways to justify higher price points for sustainable products by emphasizing quality, durability, and ethical production practices.

Limited Sustainable Footwear Options

The availability of sustainable footwear options in Europe may be limited compared to conventional footwear. Consumers may face constraints in finding sustainable styles that meet their fashion preferences and functional needs. Brands can address this constraint by diversifying their sustainable product lines and collaborating with designers.

Fashion Trends and Seasonality

The footwear industry is influenced by fashion trends and seasonality. Sustainable brands may find it challenging to keep up with fast-changing trends while maintaining their commitment to sustainable materials and ethical production. Brands need to strike a balance between staying relevant in the market and adhering to sustainable principles.

Competition from Established Brands

Established footwear brands may dominate the market and have significant resources for marketing and distribution. New sustainable brands may face constraints in competing with these giants. To overcome this, sustainable brands can differentiate themselves through unique design aesthetics and sustainability storytelling.

Supply Chain Constraints

Sourcing sustainable materials and ensuring ethical supply chain practices can be challenging. Some regions may lack suppliers specializing in sustainable materials, leading to constraints in production. Brands may need to invest in building relationships with responsible suppliers or explore global sourcing options.

Consumer Skepticism

Some consumers in Europe may be sceptical of greenwashing—when brands falsely claim to be sustainable. Sustainable footwear brands must demonstrate authenticity and transparency to overcome consumer skepticism. They can achieve this through third-party certifications, supply chain visibility, and clear communication of their sustainability efforts.

Limited Distribution Channels

Sustainable footwear brands may have limited access to distribution channels compared to larger, conventional brands. They may face constraints in securing retail partnerships. Brands can overcome this by exploring e-commerce, pop-up shops, and direct-to-consumer models.

Cultural and Regional Preferences

Different regions in Europe may have varying preferences for footwear styles and materials. Sustainable brands must consider these cultural and regional factors when designing and marketing their products. For instance, certain regions may prefer vegan or leather-free options, while others may prioritize traditional leather. Overcoming these challenges can lead to successful market penetration and growth in the sustainable footwear sector.

2.4. MASS CUSTOMIZATION AND CIRCULAR ECONOMY IN THE FOOTWEAR INDUSTRY

Mass customization is a production strategy that blends the efficiency of mass production with the personalization of bespoke craftsmanship. In the context of the footwear industry, it refers to the ability to create individualized shoes on a larger scale, ensuring that each pair is uniquely tailored to the customer's preferences and foot measurements. Unlike traditional mass production, where identical shoes are manufactured in bulk, mass customization leverages cutting-edge technologies, such as 3D scanning and 3D printing, to produce shoes that align with the specific needs and desires of each customer. This approach allows consumers to select various elements of their footwear, including style, materials, colour, and fit, resulting in a product that not only suits their fashion taste but also provides optimal comfort and performance.

Mass customization in footwear offers numerous advantages. Firstly, it addresses the issue of fit, ensuring that shoes are comfortable and supportive for individual wearers. It also caters to consumers' desire for self-expression, allowing them to create shoes that align with their personal style. Moreover, by producing shoes on-demand, the industry can reduce overproduction and minimize waste, contributing to sustainability goals. Mass customization can foster brand loyalty and customer satisfaction, as consumers value products that cater to their specific needs.

However, mass customization is not without its challenges. It requires significant investments in technology and infrastructure, which can be cost-prohibitive for some companies. Maintaining efficient production processes while accommodating customization demands can be complex. There is also the risk of overwhelming consumers with too many choices, leading to decision fatigue.

Striking the right balance between customization and standardization remains a challenge for footwear manufacturers.

Mass Customization Techniques in Footwear

Mass customization in the footwear industry involves tailoring products to individual customer preferences and needs while maintaining the efficiency of mass production processes. Several techniques and strategies enable footwear brands to offer personalized products to consumers.

- One of the most revolutionary technologies in footwear mass customization is 3D printing. Brands like Adidas and Nike have adopted 3D printing to create midsoles and uppers that are customized based on customers' foot scans. This allows for precise fitting and unique designs.
- Footwear companies utilize advanced scanning technologies to collect data on customers' feet. Algorithms analyse this data to determine the optimal shoe size, arch support, and other features.
- Many footwear brands offer online configurators that allow customers to customize various aspects of their shoes, such as colour, materials, and design elements. Customers can visualize their designs before placing an order.
- Some brands adopt a modular design approach, where shoes are composed of interchangeable parts. Customers can mix and match different components to create a unique shoe.
- In the luxury segment, bespoke shoemaking is a form of mass customization. Customers have their feet measured, and shoes are crafted entirely from scratch to their specifications. Brands like John Lobb and Berluti are renowned for this approach.

These mass customization techniques not only cater to individual tastes and comfort needs but also contribute to reducing overproduction and waste. As technology continues to advance, the boundaries of what is possible in terms of personalized footwear are constantly expanding, making mass customization an exciting frontier in the industry.

Quick Response Manufacturing is a strategy that allows for quicker response to customer demands. It involves flexible and agile manufacturing processes that can adapt to changing customer preferences. It is especially relevant for limited-edition or highly customized

Brands may set up local manufacturing facilities to enable faster production and delivery of customized footwear. This reduces lead times and the environmental impact of long-distance shipping.

Artificial intelligence and machine learning algorithms can analyse vast datasets to predict customer preferences. Brands can use this data to offer recommendations for customized designs. For instance, Shoes of Prey used AI to suggest shoe

Many footwear companies offer custom orthotic insoles designed to provide personalized support and comfort. These insoles are often created based on podiatric assessments and foot shape.

Some brands engage customers in the design process by allowing them to collaborate with designers. This co-creation approach ensures that the final product aligns with the customer's vision.

Mass Customization Techniques in Footwear

On-demand manufacturing, often known as just-in-time manufacturing, has emerged as a transformative strategy within the footwear industry, offering both compelling sustainability advantages and unrivalled customization opportunities. This progressive approach marks a significant departure from traditional mass production methods by producing footwear products in response to specific customer orders rather than generating large volumes in advance and warehousing them.

At the heart of the success of on-demand manufacturing in the footwear sector is the integration of cutting-edge 3D printing technology. This ground-breaking capability has revolutionized the creation of intricate and personalized shoe components, such as midsoles and insoles, with unparalleled precision. Brands like Adidas and New Balance have embraced 3D printing to craft midsoles tailored to individual athletes, ensuring a remarkable fit and enhanced performance. Furthermore, the on-demand manufacturing process often begins with digital foot scanning, ensuring each customer's unique foot measurements are meticulously captured. Some forward-thinking brands have even introduced online customization platforms that empower customers to design their own shoes, from materials to colours and styles, with the platform generating a digital design that reflects their preferences. Once an order is placed, it is transmitted to a manufacturing facility, where shoes are crafted to the customer's exact specifications. This localized production approach reduces transportation-related emissions and supports local economies. Notable examples include Nike's “Nike By You” and Adidas' “Mi adidas”. Sustainability is also a cornerstone of on-demand manufacturing, allowing brands to consciously select eco-friendly, recycled, or upcycled materials for production, minimizing the environmental impact of their footwear. This resolute commitment to sustainable materials and processes embodies responsible manufacturing practices, making on-demand manufacturing a sustainable and highly customizable solution for the future of footwear production.

2.5. SUSTAINABLE DESIGN SPECIFICATIONS

These specifications and guidelines outline specific objectives and targets related to sustainability, such as reducing carbon emissions, minimizing waste, conserving natural resources, and promoting fair labour practices. They provide a framework for designers, manufacturers, and other stakeholders in the footwear industry to follow when creating products that are not only aesthetically appealing and functional but also environmentally and socially responsible. Sustainable design specifications and guidelines often encompass various aspects, including material selection, manufacturing processes, durability, repairability, recyclability, and end-of-life management, aiming to align product development with sustainable and ethical principles.

Use of Sustainable	Footwear must be designed using environmentally friendly and sustainable materials, such as organic cotton, recycled polyester, Tencel, or eco-friendly leather alternatives.
Reduction of Carbon	Footwear should be designed with a focus on minimizing carbon emissions throughout the product's life cycle, including production, transportation, and use.
Durable and	The design should be durable and easily repairable, extending their lifespan.
Minimal Packaging	Sustainable footwear should have minimal packaging, with an emphasis on reducing waste.
Ethical Production	Footwear production must adhere to strict labor standards, ensuring fair wages, safe working conditions, and respect for workers' rights.

- **Vegan and Cruelty-Free Options**: Brands should offer vegan and cruelty-free footwear options in response to growing consumer demand.
- **Water Conservation**: Sustainable footwear design should consider water-efficient manufacturing processes and reduced water usage.
- **Circular Design Principles**: Footwear should be designed with circular economy principles in mind, emphasizing recyclability and upgradability.
- **Transparency and Traceability**: Brands must provide transparent information about the materials used and the entire supply chain, allowing consumers to make informed choices.
- **Collaboration for Innovation**: Brands should actively collaborate with suppliers, manufacturers, and industry organizations to drive innovation in sustainable design.

Lessons Learned from Successful Sustainable Designs

Lesson 1

Material Innovation Matters: Successful sustainable footwear designs often prioritize innovative materials that are eco-friendly and comfortable. Brands should invest in researching and sourcing sustainable materials to create appealing products.

Lesson 2

Circular Design is Key: Brands that embrace circular design principles, focusing on repairability, upgradability, and recyclability, tend to create products with longer lifespans and reduced environmental impact.

Lesson 3

Transparency Builds Trust: Transparency in the supply chain and manufacturing processes enhances consumer trust. Brands should communicate their sustainability efforts clearly to educate and engage customers.

LECTURE 3
PROCESS OF DESIGN FOR CIRCULAR ECONOMY

3.1. INTRODUCTION

Overall, the design process refers to activities that transform a theme or initial specifications into design concepts, followed by detailed drawings or sketches necessary for obtaining a new product under the given technological conditions. Artistic skills are complemented by engineering ones in the product development stage when the prototype is produced, tested and modified until an appropriate version is obtained to be manufactured. Between the development and design activity, feedback responses are established (Curteza et al., 2005[14]; Mihai et al., 2009[15]).
Design for circular economy is an approach to designing products, systems, and processes that aims to create a closed-loop system, where resources are used and managed in a sustainable and circular manner (Mederle et al., 2020[16]). It is a departure from the traditional linear "take-make-dispose" model, which leads to resource depletion and waste generation.
The concept of circular economy is based on three key principles (Mathieux et al., 2019[17]) (Figure 1):

- **Designing out waste and pollution**: This involves considering the entire life cycle of a product, from raw material extraction to disposal, and designing products and processes that minimize waste generation and environmental impact. It involves using eco-friendly materials, optimizing production processes, and creating products that are durable, repairable, and upgradable.
- **Keeping products and materials in use**: The goal is to extend the lifespan of products and materials by promoting reuse, repair, and remanufacturing. Designers need to consider how products can be easily disassembled and components can be reused or recycled. They can also explore business models such as leasing or sharing to maximize the utilization of products.
- **Regenerating natural systems**: Designing for circular economy involves considering the impact of products and systems on natural ecosystems and finding ways to support and enhance them. This can include using renewable energy sources, incorporating biodegradable materials, and implementing regenerative practices that restore and replenish natural resources.

[14] Curteza, A., Mihai, A. (2005). Design- elemente, principii, aplicatii, Performantica Publishing House, Romania. ISBN 973-730-149-8
[15] Mihai, A., Pastina, M., Sahin, M., Harnagea, M. (2009). Proiectarea incaltamintei, Performantica Publishing House, Romania. ISBN 978-973-730-465-6
[16] Mederle, K., Katschnig, J., & Braun, A. K. (2020). Circular design strategies for closed-loop product systems: A case study on recyclable footwear. Resources, Conservation and Recycling, 158, 104807.
[17] Mathieux, A., Bakker, C., & Van Arem, B. (2019). Design for circular economy in the footwear industry: A review. Journal of Cleaner Production, 208, 737-751.

Figure 20. *The concept of circular economy. Source: https://www.linkedin.com/pulse/how-circular-economy-can-kickstart-your-innovation-maria-duloquin/*

The Design and Development process of footwear collections orientated to circular economy brings up successive activities, starting with the market forecast to establish the collection's constraints due to clients. It will be followed by identifying the functional and aesthetical adequate solutions to get new products that satisfy the consumer's expectations (Curteza et al., 2005[18]; Mihai et al., 2009[19]; Chen et al., 2017[20]).

Designing the new footwear concept and developing a line collection proceed with several successive steps (Figure 2).

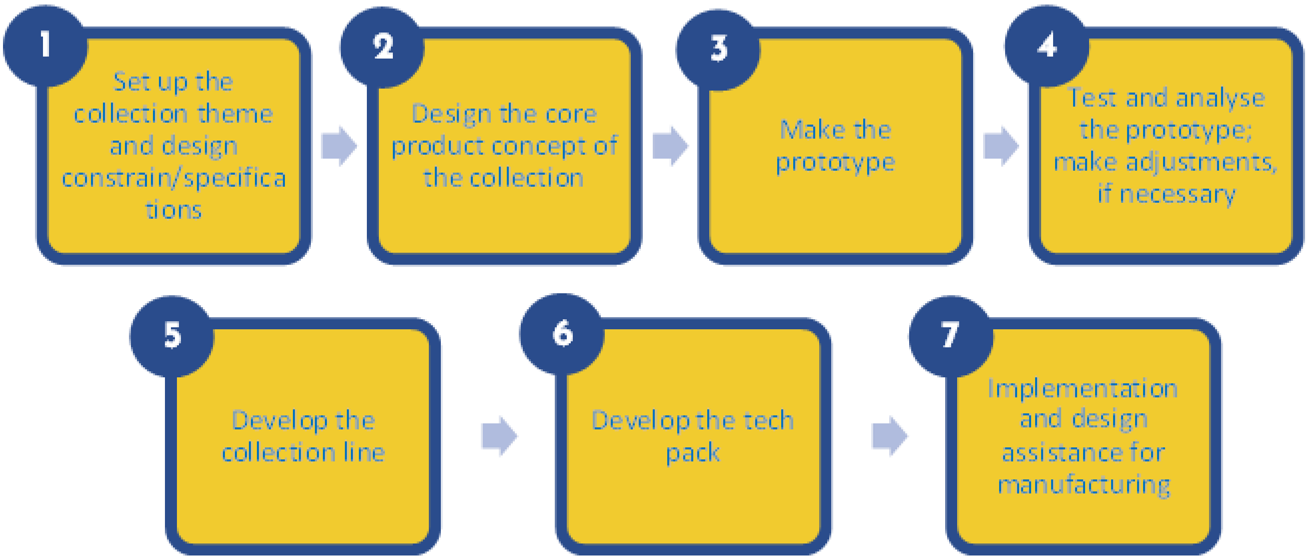

Figure 21. *Designing process steps*

[18] Curteza, A., Mihai, A. (2005). Design- elemente, principii, aplicatii, Performantica Publishing House, Romania. ISBN 973-730-149-8

[19] Mihai, A., Pastina, M., Harnagea, M., Rusu B., Volocariu, R., Dragomir, A., Ichim, M. (2009). Metode utilizate pentru conceptualizarea si dezvoltarea produselor de incaltaminte, Performantica Publishing House, Romania. ISBN 987-973-730-648-7

[20] Chen, X., & Crawford, R. H. (2017). A Review of the Design Process: How Methods Impact Design Creativity. In Proceedings of the ASME Design Engineering Technical Conferences (pp. V003T04A009). American Society of Mechanical Engineers.

3.2. PROCESS OF DESIGN

Collection theme and design specifications

Selecting a theme is challenging for designers stuck when creating a fashion collection. However, every collection has to be cohesive with the company's portfolio. This way, the company can keep the same brand image and identify the customer and its niche.

Even if design constraints or specifications may stroke the Designer's creativity, several limitations are necessary when discussing a product design to be produced in a company. Nevertheless, a good designer will know how to balance constraints and the creative process. For example, the development of a footwear collection depends on specific requirements presented in Figure 3.

Size and configuration of the market	**Budgets. Costs and estimated selling prices**
Style and fashion trends	**Functionality and ergonomics: main functions against specific purposes of the footwear to be suitable to human comfort**
Manufacturing requirements	**Innovative features as new materials, components and technologies that company have access to**

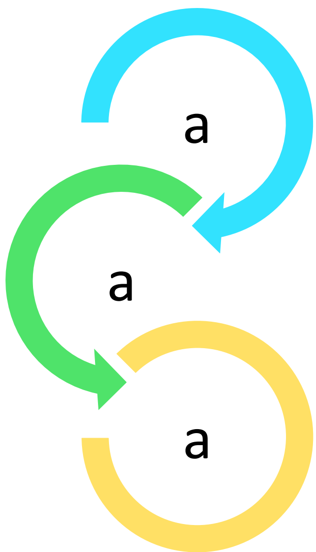

Figure 22. *Requirements for development of a footwear collection.*

The collection development begins with establishing a mood and an atmosphere that fits the customer's lifestyle and specific design aesthetic. Thus, finding the inspiration theme consistently and coherently will help people recognise the brand. A **mood board** (Figure 4) is a collection of visual elements that illustrate the design concept, including colours, textures and images.

Figure 23. *Example of a mood board. Credit: TUIASI- Tudor Vatavu*

Design the core product concept of the collection

Inspiration is everywhere, and the Designer has to observe and absorb it. A photo diary, inspirational book for unique ideas, references for shapes in colours or possible combinations of colours are just some tools a designer may use to create the collection's core product. Photos, for example, show possible construction elements of the footwear upper or sole and could be texture elements.

The next stage after collecting ideas and making sketches is to elaborate a visual story called a **concept board**. It continues the same story heightened within the mood board.

The example below presents the concept board against the mood board. The title of the collection is **3R: Rethink. Reuse. Rebuild**. The design concept proposes reusing and integrating local materials, resources and wastes to make comfortable footwear with shock-absorbing and plantar pressure distribution properties to facilitate long-term wear (SciLED, 2021[21]).

Figure 24*. Concept board for a design theme committed to the circular economy. 3R: Rethink. Rebuild. Reuse. Credit: TUIASI- Alexandru Urma, Marin Cojocari and Diana Misiru*

[21] SciLED project. (2021). Footwear in the 21st century. New skills for the scientifically-led design of comfortable, sustainable and fashion-oriented footwear products, 601137-EPP-1-2018-1-RO-EPPKA2-KA. Retrieved from https://sciled.eu/

Make the prototype

Three-dimensional (3D) prototypes are necessary at the product development stage to evaluate, test and assess the new product against specific criteria, such as functionality, costs, and manufacturing constraints. In the first step, a virtual 3D prototype, appropriately rendered, could give preliminary information on appearance, colours, texture and shapes. In the second step, the physical prototype (Figure 6) could asses functionality by trial, fitting and testing (TCLF, 2021[22]).

Testing and Analysis

The capacity of footwear products to meet consumer expectations is prepared from the creative phase, where different methods for analysing the collection are used. The product evaluation occurs between the prototype development and the industrial implementation stages. It is a critical stage as it removes the possibility of improper products: functionally (F), aesthetically (E), and expressively (E). First, a so-called FEE analysis pattern of consumer needs is implemented. Next, the prepared portfolio that contains drawings, sketches, mock-ups and prototypes has to be analysed to select only those concepts that respond to initial design specifications. Then, technological, financial, and marketing analysis completes the decisional process for the following steps.

Figure 25. *A physical prototype of a footwear product designed with adherence to circular economy principles. Credit: TUIASI- Alexandru Urma, Marin Cojocari and Diana Misiru*

[22] Skills4Smart TCLF project. (2021). Skills for Smart Textile, Clothing, Leather and Footwear Industries, 591986-EPP-1-2017-1-BE-EPPKA2-SSA-B. Retrieved from http://www.s4tclfblueprint.eu/

Develop the collection line

Footwear collection development without considering specific elements of the different design domains (clothing, textile) leads to break-off and incorrect positioning on the market. Therefore, selecting the optimal solution from multiple variants is sustained by the following:

- **Collection statement:** A good collection must have a consistent and recognisable signature, apart from other designers and brands. The Designer should keep the same design elements for the entire collection, such as iconic/brand signature, colour theme, shapes, patterns, manufacturing or handcrafted techniques, materials or motifs.
- **Multi-item character:** Many collections revolve around a single product in various colours and/or combinations. In the case of multi-item collections, a statement piece (product concept), keeping with the main design inspirational theme, could hold all the other items of the collections altogether.
- **Collection size:** There is no magic number. The size is essential but does not impact the collection's presentation. Depending on the brand, sometimes "less is more".
- **Design for Manufacturing** is a method for developing a collection line to reduce production costs. Also, this method offers solutions for creating footwear models starting from a core design concept by **applying a logical framework** on how these models are related to each other.

Design assistance for manufacturing

Technological restrictions may occur where product design modification is required at the manufacturing stage to avoid technical problems or to improve cost-effectiveness.
The designers should assist the production team in making the right decisions on manufacturing parameters such as quality, time, cost and environmental impact. Also, all necessary materials and tools for manufacturing are established in this stage.

3.3. EMERGING TRENDS IN FOOTWEAR DESIGN FOR CIRCULAR ECONOMY

Back in the '60s, when the motto of fashion collections was **"plastic is fantastic!"** sustainable design was subjected to speculative talks or ethical questions. Nowadays, the increase in the consumption of materials and energy, as well as the enormous environmental pollution, has reached such a high level that it is imperative to protect our lives. Therefore, applying sustainable principles in product design allows companies to get a new level of performance and enter the competition again. As a result, consumers will begin to ask for more ecological products ("eco-friendly"), and manufacturing companies must meet these new requirements.
Being environmentally friendly means making decisions that will not affect the environment. It is also a marketing concept that refers to products, services, laws, public politics and orientations that do

not cause any harm to ecosystems (Gupta et al., 2021[23]). For example, the main directions where a footwear company could act are presented in Figure 7.

rational use of natural resources

recycling biodegradable waste

minimum use of plastic material

using recyclable packaging materials

using biomass and solar radiation as renewable energy sources

generating electricity from hydroelectric plants

reducing toxic emissions

Figure 26. *Environmentally friendly directions for footwear sector.*

From the perspective of product development, the following **values support a sustainable design (**Aparicio et al., 2019[24]) (Figure 27):

- **Traceability of materials, components and final products.** Certification on fair trade practices, the origin of materials sourcing and transparency all over the supply chain are requirements that the footwear companies must comply with.
- **Water and energy efficiency.** From the design stage, the new footwear product can be planned in such a way as to be more efficient in terms of energy or water consumption. For example, manual stitching could replace specific seams made by machines. This way, traditional handcrafts are reinvigorated more sustainably. In addition, certain finishing operations that require water consumption can be replaced with other technologies, even when the product is only imagined on the Designer's drawing board.
- **Selecting materials for comfort and environmental performance.** Leather is the raw material traditionally used in footwear. However, recent research shows high functionality does not conflict with environmental performance.

[23] Gupta, M., Kamaraj, M., & Sarangan, V. (2021). Sustainable footwear design: A systematic literature review. Materials Today: Proceedings, 46(2), 1143-1148.

[24] Aparicio, V., Batlle-Bayer, L., & Segalàs, J. (2019). Designing for circular economy in the footwear sector: An exploratory study. Sustainability, 11(14), 3954-3967.

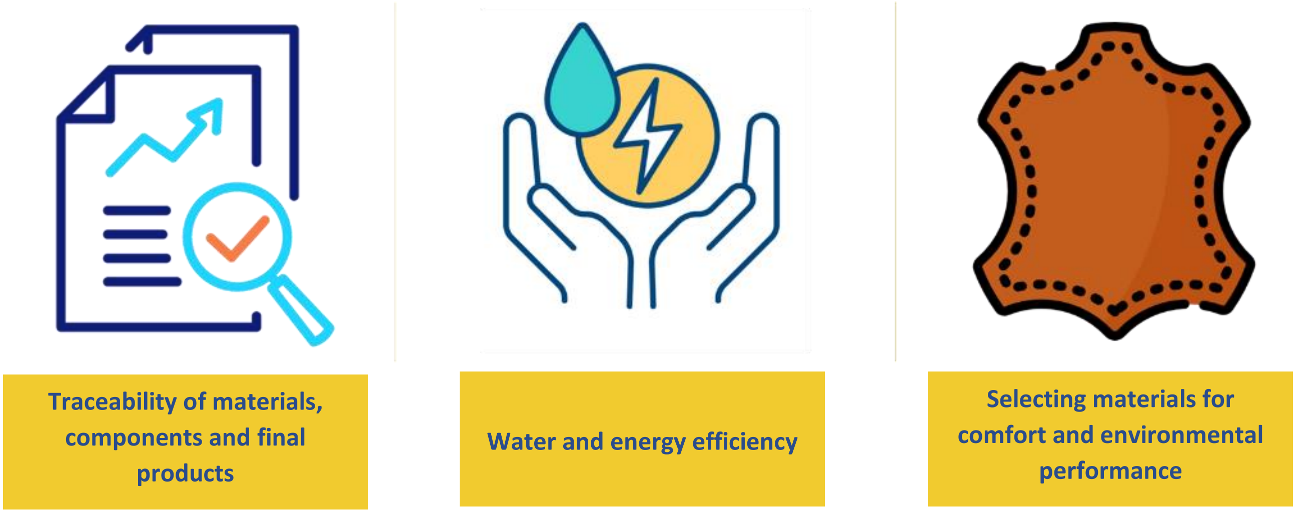

Figure 27. Values applied to support a sustainable design in footwear development

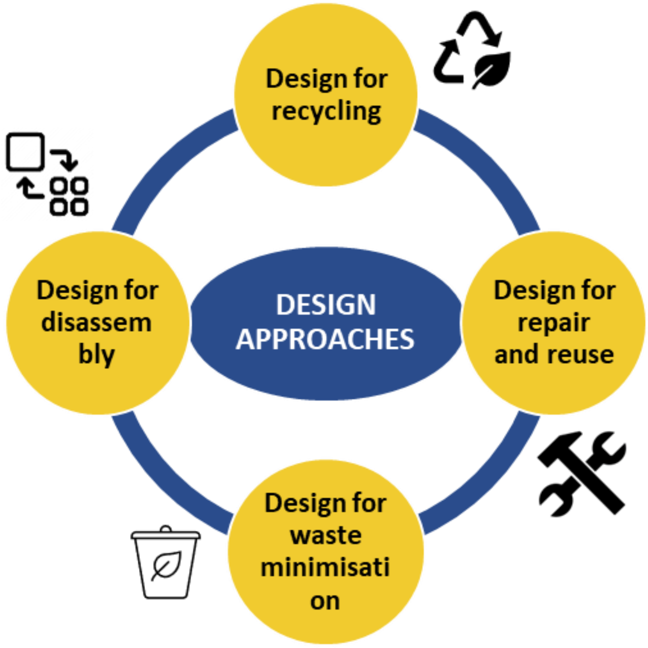

Figure 28. *Design approaches for circular economy in footwear sector.*

When fashion complements environmental responsiveness, the result is enriched. From now on, it is a truism that the fashion industry is responsible for about 10% of all greenhouse gas emissions. Therefore, selecting the materials not just based on fashion and comfort criteria but also their sustainability performance and environmental impact is a real commitment for all designers. The most suitable design approaches for circular economy in footwear sector are: design for recycling, repair and reuse, waste minimisation, disassembly (Bouteille et al., 2020[25]) (Figure 28).

Design for recycling

Zouri brand – sneakers with soles from ocean plastics. Source: https://secretsfromportugal.com/zouri-the-portuguese-brand-that-transforms-plastic-from-ocean-into-stylish-shoes/

After hundreds of years of consuming the earth's natural reserves to near exhaustion, we are now finding valuable resources from the wastes that can be recycled and exploited to a new value.

For example, the Portuguese company ZOURI (Figure 10) has turned ocean plastics into a material used for footwear soles. The brand proudly promotes that" ***each pair reuses the equivalent of six plastic bottles taken from the ocean".***

Design for repair and reuse

FVivobarefoot brand – reborn concept. Source: https://www.vivobarefoot.com/rw/our-repairs-service

Design for repair and reuse involves designing products with durability and longevity in mind and incorporating features that allow for easy repair and maintenance. Design for repair and reuse encourages manufacturers to create products that can be easily repaired, upgraded, or repurposed rather than being discarded and replaced when they break or become outdated.

Footwear companies could offer various ***repair services***, including ***cleaning, resoling and repairing stitching***.

[25] Bouteille, R., Bakker, C., & Donke, T. (2020). Circular design strategies for footwear: A case study of sustainable sneakers. Sustainability, 12(19), 8054.

Reebok brand – footwear made from things that grow (cotton + corn). Source: https://www.youtube.com/watch?v=DN6dUVlawdg&ab_channel=Reebok

Design for waste minimisation is a concept that focuses on creating products, processes, and systems that generate as little waste as possible during their lifecycle.

To reduce waste, companies are:

- choosing materials that are durable, recyclable, and biodegradable;
- simplifying the design; incorporating reused or recycled materials into the design;
- reducing energy use and optimising manufacturing processes;
- planning for the end-of-life disposal of the product.

Design for disassembly

Nike ISPA Link- disassembled footwear. Source: https://fashionunited.uk/news/fashion/why-nike-designed-a-sneaker-that-is-made-to-be-disassembled/2022052363238

Design for disassembly is a design approach that focuses on making products with components that may be taken apart for repair, reuse, or recycling at the end of their lifecycle. The goal is to facilitate the separation and recovery of different materials and components so that they can be reused or recycled instead of ending up in landfills.

For example, Nike is experimenting with 3D printing and modular design to create shoes that can be easily disassembled and recycled.

For instance, Reebok has implemented several design strategies to reduce waste, such as using recycled materials in its products, designing shoes that can be easily disassembled and recycled, and offering a "Cotton + Corn" collection made from plant-based materials.

LECTURE 4
SELECTING SUSTAINABLE MATERIALS AND TECHNOLOGIES FOR ECO-FRIENDLY FOOTWEAR

4.1. INTRODUCTION

The materials used during the footwear manufacturing process can be divided into two categories: main materials and auxiliary materials.

Figure 29. *Footwear material's main types*

The main materials that are used in the process of footwear manufacturing can be divided as follows:

- natural leather, which can be flexible leather and rigid leather;
- leather substitutes, flexible and rigid, with characteristics similar to the leather
- textiles, with a wide range of structures, following their different usage purposes.

The auxiliary materials that are used in footwear manufacturing include joining, finishing, and adorning materials.
The joining materials comprise threads, adhesives, different accessories, laces, and strings.
Finishing materials include cleaning fluids, solvents, waxes, paints, and fullness materials.
Adorning materials comprise different accessories, made of plastics, wood, metals, or other kinds of materials. The footwear materials must have proper physical, mechanical, and chemical properties, which are useful, both during the manufacturing processes and wearing[26].

Figure 30. *Recycled footwear. Source https://www.the-sustainable-fashion-collective.com/2016/10/31/recycled-footwear-fever-developments-shoe-materials-2.*

[26] Costea M., Mihai A., *Basics of footwear modelling and pattern making*, TEHNICA-INFO Publishing House, Chișinău, Republica Moldova, 2016, ISBN 978-9975-63-394-9

4.2. LEATHER: DEFINITION AND CLASSIFICATION

Leather is a material that is resistant to putrefaction and enzymatic destruction and after repeated wetting drying returns back to its former soft characteristics.
The tanning processes convert the rawhide and skin into a material that doesn´t putrefy, even after drying and wetting. The skins when converted into leather become a hard, brittle material, but remain flexible and workable, after drying[27].

To obtain leather hides from cows, pigs, ovine, goats, equines, and reptiles are used after undergoing a tanning process, which is a complex process comprising physical, chemical, and mechanical procedures. The finite leather can be classified, after the degree of flexibility, into flexible and rigid leather. The flexible leather is used in manufacturing footwear uppers and linings as well. The rigid leather is used for soles, insoles, counters, toe caps, and heel pieces.

Leather is a material used on the production of footwear, which results from the tanning of animal's hides or skins.

The type of tanning process is important for the final properties of leather materials, namely, softness, hardness, tightness and stretching.

The leather tanned in chromium salt is thinner, softer, and extensible; it also has a higher resistance to tearing and breaking, it has good water and air vapor permeability, it has water permeability and a reduced capacity of thermal isolation.
The leather tanned with vegetal products is thicker, heavier, has a higher capacity for plastic deformation, has better thermal isolation, is more stable under the action of humidity than the one tanned with chromium salt, and is less resistant and less elastic.

Sources and types of conservation of hides and skin. Recommendations for lower environmental impact. If possible, no hide or skin conservation (fresh) is the most environmentally friendly option. Because there is no need to rehydrate the skin and eliminate the conservation salt. However, this option is only possible if the hide or skins are used within a few hours after being removed from the animal[28].

The country's origin and transportation (plane, boat, or truck) are also crucial for carbon footprint.

[27] Step2Sustainability Project - How to Implement Sustainable Manufacturing in Footwear, 539823-LLP-1-2013-1-PT-LEONARDO-LMP

[28] Bacardit A., Baquero G., Sorolla S., Ollé L., Evaluation of a new sustainable continuous system for processing bovine leather, Journal of Cleaner Production 101 (2015).

Hides or skins of European origin are, normally, of high quality.

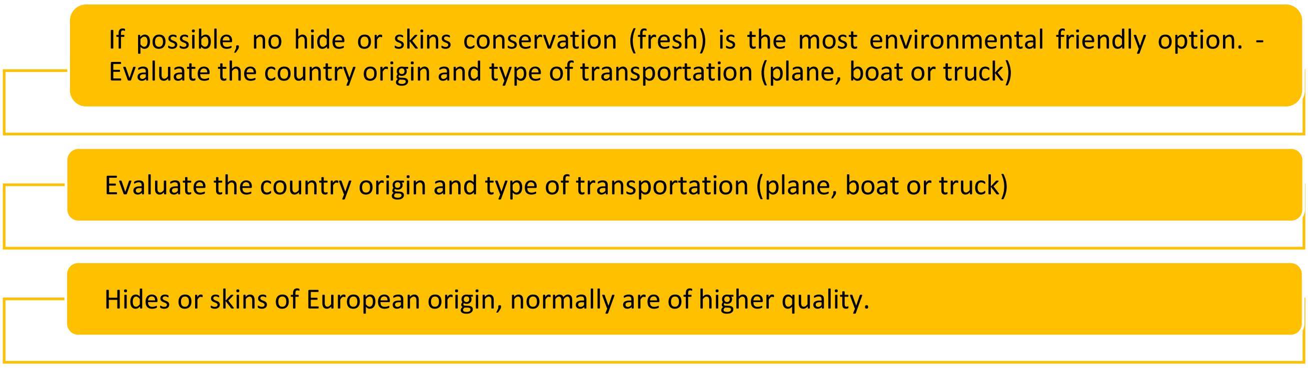

Figure 31. *Recommendations for lower environmental impact*

Leather is a natural product and is made by converting animal skins or hides through tanning which consists of various mechanical and chemical operations.
Production of leather is a long and complicated process, and certainly not one that can be embarked upon successfully without specialization skills.

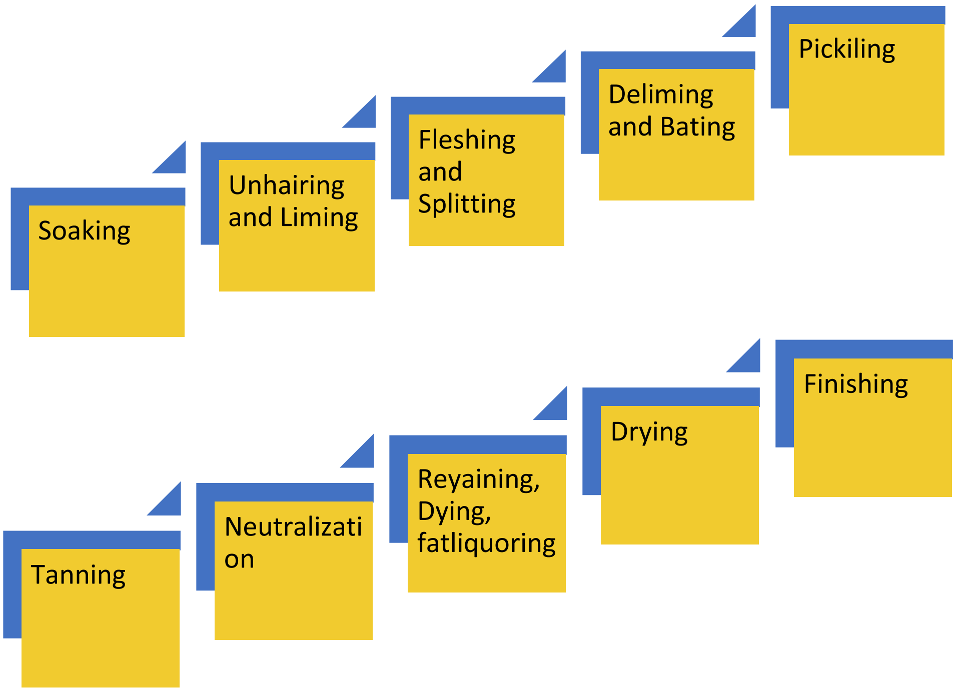

Figure 32. *Leather manufacturing - Production Stages*

The tanning process converts unstable raw hides into leather, with adequate strength properties and resistance to various biological and physical agents. The leather stabilization is achieved, mainly, by increasing the water resistance and limiting the swelling. The tanning process leads to changes in appearance, handling, and touch of the skin or other tissues. The skin becomes rougher and loses transparency drying. Compared with the wet state, there is a loss of flexibility but at the same time acquires a certain porosity[29]. The leather process is a complex and time-consuming process that is performed over several stages, and in which is used a large variety of chemicals. The leather manufacturing process includes three phases, namely the beamhouse (preparation of hide or skins), tanning, and finishing (in post tanning area).

Leather: Environmental impact

The tanning process comprises the preparation and processing of considerable amounts of chemicals and enormous volumes of water and generates significant pollution loads. In tanning manufacturing the average uptake of leather chemicals in an aqueous medium is about 65-75%, leading to the generation of wastewater and pollution load generation of wastewater with high pollution load. On the other hand, leather manufacturing consumes 30-50 liters of water per kg of raw hide or skin[30].

A great amount of sludge generated from tannery plants makes solid waste management very inactive due to the non-biodegradability of leather. Also, during the tanning process, several pollutants are emitted into the atmosphere from tannery plants as effluents such as ammonia, hydrogen sulfide, volatile hydrocarbons, amines, and aldehydes[31].

To reduce the negative impact of the leather production process can be followed two approaches, namely, avoid the use of harmful chemicals and produce solid wastes which can be used as by-products and treatment of wastewater and the environment-friendly handling and processing of solid waste[32].

Environmental issues associated with tanning and leather finishing

- **Wastewater**
- **Air emission**
- **Solid waste**
- **Hazardous materials**

Figure 33. *Environmental issues associated with tanning and leather finishing*

[29] Basegio T., Leão A.P.B, Bernardes A.M., Bergmann, Vitrification: An alternative to minimize environmental impact caused by leather waste industry wastes, Journal of Hazardous Materials 15 (2009).

[30] CADS – Cooperation at DSI Deutsches Schuhinstitut, Recommendations for the avoidance of Chromium (VI) formation, Germany (2015).

[31] Sathish, M., et al., Alternative carrier medium for sustainable leather manufacturing – a review and perspective, Journal of Cleaner Production (2015), htto://dx.doi.org/10.1016/j. jclepro2015.06.118.

[32] Rahimifard, S.; Staikos, T.; Coates, G., Recycling of Footwear Products. A position paper prepared by the Centre for Sustainable Manufacturing and Reuse/recycling Technologies (SMART) Loughborough University, Leicestershire, UK (2007).

Recommendations for lower environmental impact

- Select leather from companies that accomplish ecological criteria and requirements; sustainable processes and good environmental practices.
- Select leather companies that use skin raw material from countries close to decrease the transportation carbon footprint.
- Use of more natural leather without too much finishing product applications.
- Use high-quality and durable leather.
- Use of leather without restricted and hazardous substances.
- Use of ecolabel leather.
- Use thinner leather materials.
- Use of biodegradable leather.Good use of the leather area during the cutting process to reduce the leather waste.

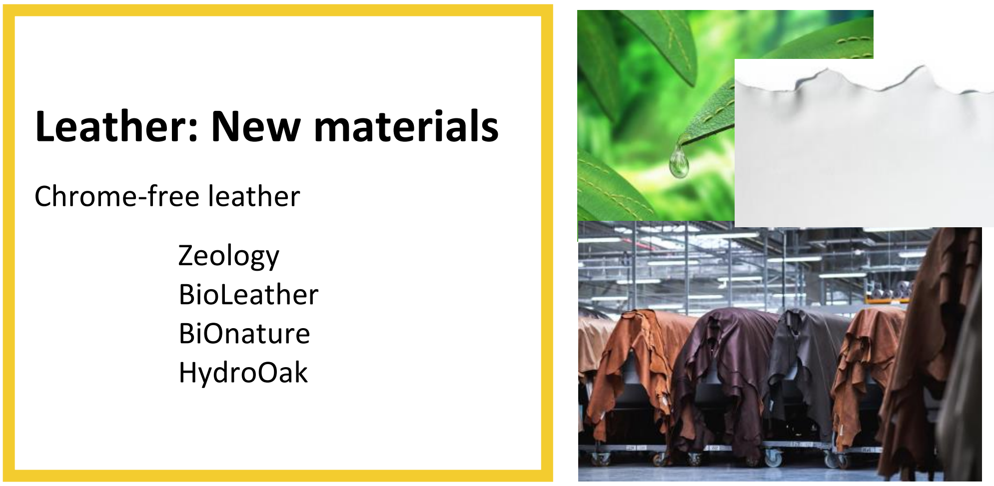

Figure 34. *Zeo White, Zeology (chrome free) tanned leather.*
Credit: https://www.neratanning.com/chrome-free-leather/

In the framework of Be Nature, a Portuguese R&D project was developed by António Nunes de Carvalho, a disintegrable and biodegradable chrome-free leather, called Bionature. The same company also developed a chrome-free leather with improved water resistance properties. The Bioleather is also a chrome-free leather commercialized by Curtumes Aveneda[33].

Zeology-tanned leather[34] - Zeology, the leather tanning agent, is chrome-free, heavy metal-free, and aldehyde-free and does not compromise on leather performance. Zeo White's bright white color enables white leather and lighter and brighter colors than were ever possible before.

[33] https://www.aveneda.com/

[34] https://www.neratanning.com/zeology/

4.3. TEXTILES AND SYNTHETICS. RECOMMENDATIONS FOR LOWER ENVIRONMENTAL IMPACT

Textile materials refer to materials that are susceptible to being transformed into yarns and posterity in woven. These materials are, essentially, all types of fibers of **natural** origin (vegetable, animal, or mineral), **chemical** origin (obtained from natural and synthetic polymers), or **metallurgical** origin (obtained from inorganic substances by metallurgical technology)[35].

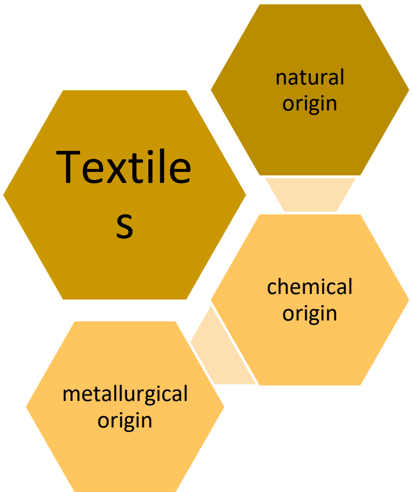

Figure 35. *Fibres origin*

Sustainable textiles and synthetics should be environmentally friendly and respect social and environmental quality, preventing or controlling the level of pollution. Additionally, should take into account the Restricted Substances Lists (RSLs) that connect the production ecology to human ecology. The Restricted Substances Lists promote the safer use of chemicals and the verification of materials cleaner production.

To develop and produce footwear with lower environmental impact some recommendations should be followed, to select the textiles and synthetic materials:

[35] Mather R.R. & Wardman, The Chemistry of Textile Fibres, Royal Society of Chemistry, 2º ed., Cambridge (2015).

Without or with minium amount of active chloride and other active halogen compounds

With biodegradable materials in substitution of aggresive chemicals

Without all carcinogenic or potentially carcinogenic chemicals and dyes

Without or with minium amount of formaldehyde compounds

Without dyestuffs containing heavy metal ions

Sustainable fibres: Biodegradable, recyclable and reycled

More natural, durable and light materials

Figure 36. *Recommendations for lower environmental impact*

Textile production in general has an environmental impact, including energy, toxic chemicals, land/natural resources, and water. Nowadays new materials are becoming available in the market from eco-friendly fibers and processes. Even these choices are not clear-cut. These types of fabric represent positive change but have drawbacks.

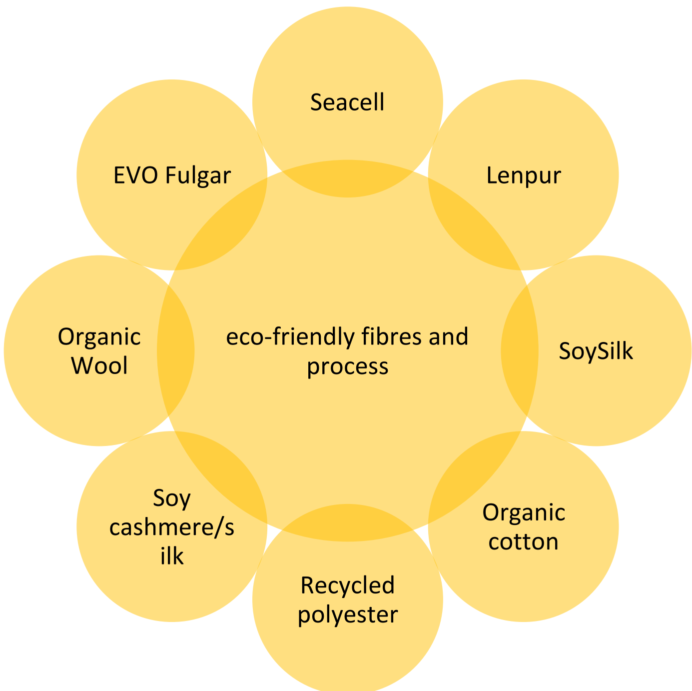

Figure 37. *Eco-friendly fibers*

Nowadays new materials are becoming available in the market, New eco-friendly fibers and processes, as example we could mention:
Seacell - This fiber is derived from wood pulp and seaweed (algae) and diffuses its protective and anti-inflammatory properties into the skin, stimulating the metabolism.
Lenpur - This biodegradable fabric is made from white pine tree clippings, and "offers the comfort of silk, the touch of cashmere and the lightness of linen." Lenpur's website states that it's a cut above the other cellulose fibers due to its softness, absorption capacity, ability to release dampness, and ability to sustain a higher thermal range —thus keeping you cooler in the summer and warmer in the winter.
SoySilk - this lesser-known 100% biodegradable eco-friendly fabric is made from tofu-manufacturing waste. Soy protein is liquefied and then stretched into long, continuous fibers that are cut and processed like any other spinning fiber. Because soy has a high protein content, the fabric is very receptive to natural dyes, so there's no need for synthetic dyes.
Organic cotton - More than 25 percent of the world’s pesticides are used in conventional cotton production. Organic cotton is grown without toxic, synthetic chemical inputs. Look for natural dyes or colored cotton to further reduce the amount of chemicals dumped into our ecosystem.
Recycled polyester - This fiber is made from cast-off polyester fabric and soda bottles, resulting in a carbon footprint that is 75 percent lower than virgin polyester. Recycled polyester contains toxic antimony, but some companies are working on removing it from their fabrics.
Soy cashmere/silk - This fabric is made from soy protein fiber left over after processing soybeans into food. The soy may be genetically engineered unless noted on the label.
Organic Wool - Wool is renewable, fire-resistant, and doesn’t need chemical inputs. Look for chlorine-free wool from humanely treated animals. Organic wool is increasingly becoming available: it is produced using sustainable farming practices and without toxic sheep dips.
EVO by Fulgar – Fulgar, a leader in the synthetic fiber market, has developed EVO, an innovative high-performance fiber made of a biopolymer derived entirely from castor oil seed. Castor oil has traditionally been used as a laxative and in many other applications ranging from soaps and lubricants to paints and dyes.
Even these choices are not clear-cut, says The Nature Conservancy. These types of fabric represent positive change but have drawbacks.

4.4. SOLES AND MIDSOLES

To produce more sustainable soles for footwear some recommendations should be followed, namely:

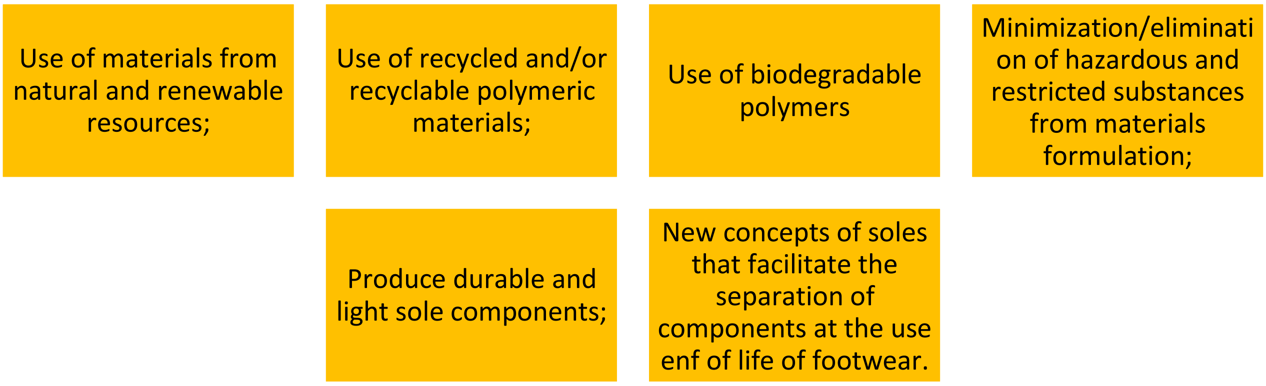

Figure 38. *Recommendations for lower environmental impact of soles*

Increased awareness of the need to honour the earth in all areas, including clothing and footwear manufacturing, has spurred high consumer demand for shoes that are eco-friendly in materials, processing, and packaging—green shoes if you will. The ecological part weighs increasingly on shoe-making worldwide, and there are already a lot of companies focusing on recyclable materials, particularly for the soles. "More than 60% of the soles used today seem rubber are made of thermoplastic and recyclable materials. Even when using rubber try always to be also recycled."

Also, customers in search of earth-friendly footwear now have an extensive array of options: recycled footwear (most are made from old tires), hemp shoes, vegan shoes (no animal products are involved in the process or packaging), and more. A quick Internet search reveals many truly creative, innovative, and earth-friendly solutions that different manufacturers are offering:

Companies that make the soles—or the entire shoe—from recycled tires, or recycled foam and rubber from factory floor droppings.

Companies that take it a step further and integrate ultra-sustainable ingredients such as hemp and bamboo, which utilize fast-growing plant crops.

Companies that offer biodegradable baby footwear made of natural latex rubber that dissolves when the baby grows out of it.

Companies that focus their efforts on fair trade and fair factory labor practices.

4.5. FOOTWEAR COMPONENTS AND ACCESSORIES. RECOMMENDATIONS FOR LOWER ENVIRONMENTAL IMPACT

Components and accessories in footwear have a fundamental part in footwear, although they are less “visible”. The components and accessories of footwear include toe puffs, stiffeners, heels, and shanks, which, while less apparent, are nonetheless important.

To develop more sustainable footwear products some recommendations should be followed, namely:

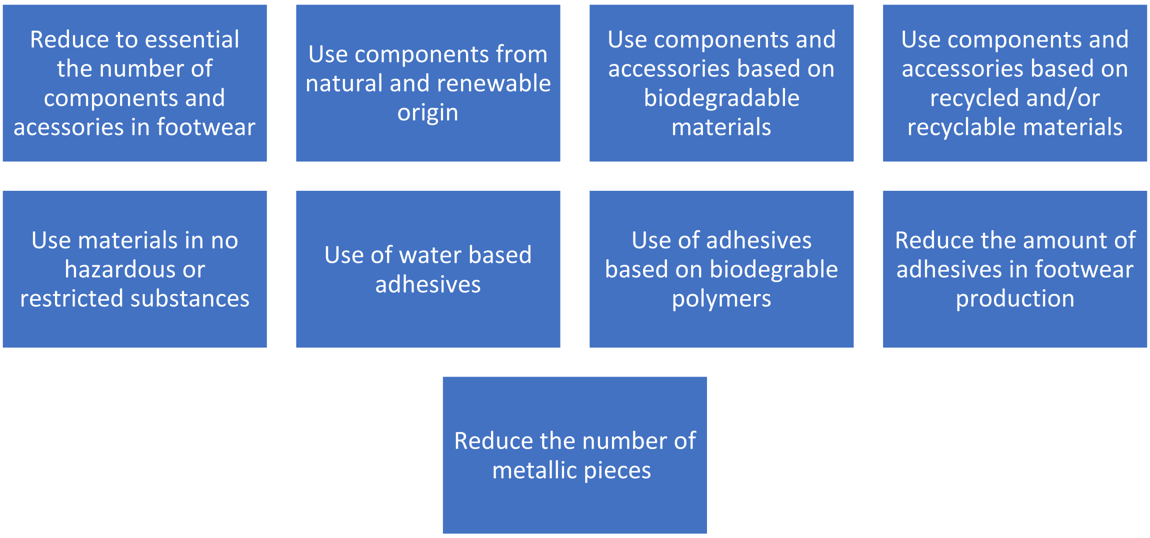

Figure 39*. Recommendations for lower environmental impact of accessories*

4.6. MISCELLANEOUS COMPONENTS AND ACCESSORIES: ADHESIVES

As the trend of environmental legislation at a global level to take increasingly stringent measures and tighten the control of pollution in the emissions of volatile organic compounds (VOCs) have been increasingly being reported is of great interest to the industry the adoption of practices which enable it to competitive way to address such restrictions.
Globally two things can be made:

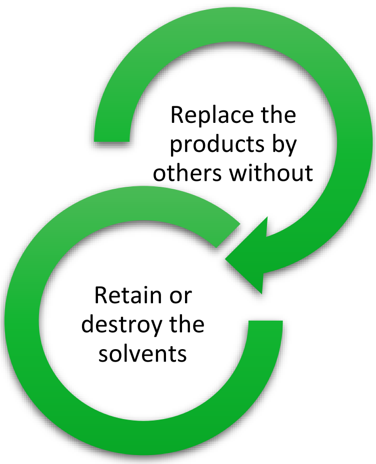

Figure 40. *Recommendations for lower environmental impact of adhesives*

The evaporated solvents from glues and other solvents used in the footwear industry contaminate the working atmosphere, and their emission into the atmosphere contributes significantly to environmental pollution. To minimize the risks associated with flammability and toxicity of these products are auxiliary systems for extraction and recovery of VOCs.

As the trend of environmental legislation at a global level to take increasingly stringent measures and tighten the control of pollution in the emissions of volatile organic compounds (VOCs) have been increasingly being reported is of great interest to the industry the adoption of practices which enable it to competitive way to address such restrictions.

Being economically penalizing the use of auxiliary exhaust systems, retention, and disposal of solvents is more viable to replace toxic products with less hazardous

LECTURE 5
PROTOTYPING, TESTING AND ANALYSIS

5.1. INTRODUCTION

Prototyping, testing, and analysis (Figure 1) are essential components of the footwear design process that ensure the development of high-quality and functional products. These stages involve creating physical or virtual prototypes, subjecting them to various tests, and analysing the results to make informed design decisions[36],[37].

Prototyping involves creating physical or digital representations of footwear designs to visualise, assess, and refine concepts. Depending on the design phase and the level of detail required, prototypes can range from basic sketches to intricate 3D models or even functional mock-ups. Prototypes help designers and stakeholders better understand the design's form, fit, and overall aesthetics[38].

Footwear testing involves subjecting prototypes to a variety of assessments to ensure they meet performance, comfort, and safety standards. After testing, the data collected is analysed to understand how the footwear performs under different conditions. This analysis provides insights into areas that require improvement or modification.

Testing and analysis ensure that the final product aligns with sustainability goals, meets performance requirements, and functions as intended throughout its lifecycle. By rigorously evaluating prototypes through testing and analysis, designers can identify potential weaknesses, refine designs, and make informed decisions to improve the overall quality of the product. In the context of circular economy principles, testing and analysis are particularly important to create products that can be repaired, reused, or recycled effectively[39].

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[36] Curteza, A., Mihai, A. (2005). Design- elemente, principii, aplicatii, Performantica Publishing House, Romania. ISBN 973-730-149-8

[37] Mihai, A., Pastina, M., Harnagea, M., Rusu B., Volocariu, R., Dragomir, A., Ichim, M. (2009). Metode utilizate pentru conceptualizarea si dezvoltarea produselor de incaltaminte, Performantica Publishing House, Romania. ISBN 987-973-730-648-7

[38] Lauff, C. A., Knight, D., Kotys-Schwartz, D., & Rentschler, M. E. (2020). The role of prototypes in communication between stakeholders. Design Studies, 66, 1-34.

[39] Paramount (2023). The ole of Quality Control in Footwear Testing. Retrieved from https://paramountinstruments.com/blog-detail/role-of-quality-control-in-footwear-testing

Figure 41. *Prototyping, testing and analysis.*

5.2. PROTOTYPING

The prototyping phase is a crucial step in the design process of any product, including footwear. It involves creating physical or digital models of the product to test and refine its design, functionality, and performance before moving to the production stage. In the context of footwear design, prototyping serves as a bridge between concept and reality, allowing designers to visualise their ideas in tangible forms and identify potential issues early in the process.

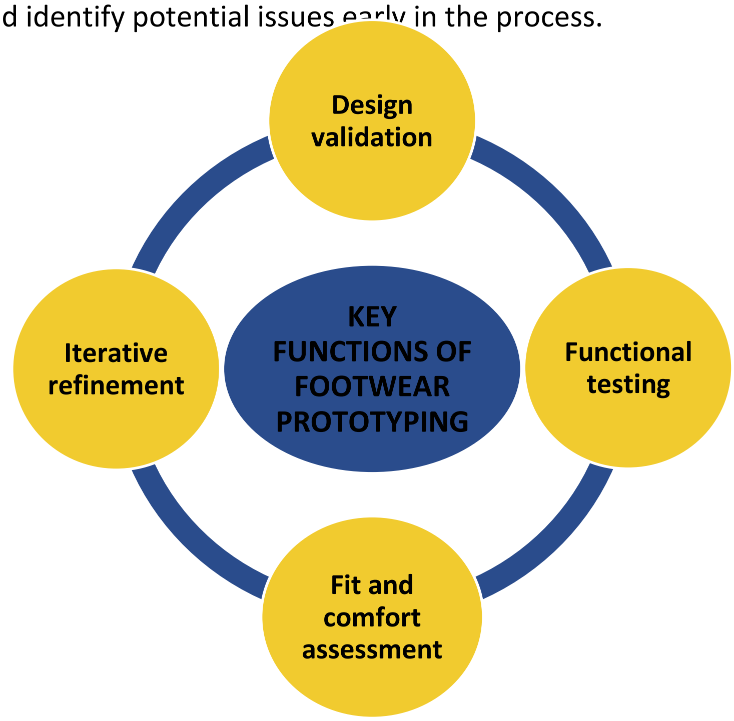

Figure 42. *Key functions of footwear prototyping.*

During the prototyping phase, designers have the opportunity to experiment with different materials, structures, and features. This iterative process helps refine the design and ensures that the final product meets the desired objectives and user expectations. Prototyping not only aids in refining the aesthetics and functionality of the footwear but also plays a significant role in aligning the design with circular economy principles[40].

Prototyping techniques for footwear

In footwear design, various types of prototyping techniques can be employed to create physical or digital representations of the product. These prototypes serve different purposes at different stages of the design process. The common types of prototyping used in footwear design are: physical and digital prototyping.

Physical prototyping

Figure 1. *Physical prototype of a footwear product designed with adherence to circular economy principles. Credit: TUIASI-Alexandru Urma, Marin Cojocari and Diana Misiru*

A physical prototype is a tangible, three-dimensional representation or model of a product, design, or concept that is created during the product development process. It is built to visually and physically demonstrate the intended characteristics, features, and functionality of the final product. Physical prototypes are often constructed using materials similar to those that will be used in the actual product, allowing designers, engineers, and stakeholders to assess and evaluate various aspects of the design, such as aesthetics, ergonomics, functionality, and fit.

Physical prototypes can range from basic mock-ups made with simple materials to highly detailed and functional representations that closely resemble the final product (Figure 4). They play a crucial role in design validation, testing, and communication, enabling to better understand the product's form and function and make informed decisions about its development[41].

Concept models: These are basic physical representations of the design concept. They help designers visualise the general shape, form, and proportions of the footwear.

[40] Coughlan, P., Suri, J. F., & Canales, K. (2007). Prototypes as (design) tools for behavioral and organizational change: A design-based approach to help organizations change work behaviors. The journal of applied behavioral science, 43(1), 122-134.

[41] Lauff, C.(2018). Prototyping in the Wild: the Role of Prototypes in Companies.

Mock-ups: Mock-ups are created using inexpensive materials to represent the overall structure and feel of the footwear.

Functional prototypes: These prototypes are more advanced and are created using materials similar to the final product. They allow designers to test aspects like cushioning, support, and overall performance.

3D printed prototypes: 3D printing technology allows designers to create accurate and intricate prototypes layer by layer. This is useful for testing complex shapes and designs.

Wearable prototypes: These are more refined prototypes that closely resemble the final product. They can be worn for testing comfort, fit, and functionality in real-world conditions.

Figure 43. *Types of physical prototypes*

Digital prototyping

Figure 2. *Digital prototype of a footwear product designed with adherence to circular economy principles.*

Credit: TUIASI- Maria Popa

A digital prototype is a virtual representation or simulation of a product, design, or concept that is created using digital tools and software. Unlike a physical prototype, which is a tangible three-dimensional model, a digital prototype exists in a digital environment and is composed of virtual components and data. The main software used for footwear virtual prototyping are: ICad3d+, MindCAD, Romans CAD, as well as Rhino, Maya, etc.

Circular economy principles for prototyping

In the context of circular economy principles, the prototyping phase takes on an added layer of importance. Circular economy aims to minimise waste and promote the longevity of products by creating closed-loop systems where resources are reused, repurposed, and recycled[42]. Designing prototypes that align with circular economy principles is a proactive way to contribute to a more sustainable and environmentally friendly design approach. The key circular economy principles emphasized during the prototyping phase are presented in Figure 6.

By emphasising these principles during the prototyping phase, designers lay the foundation for creating footwear products that align with the circular economy's goals of reducing waste and maximising resource efficiency. The iterative nature of prototyping also means that designers can continuously refine these aspects based on testing and user feedback, leading to more environmentally friendly and sustainable end products.

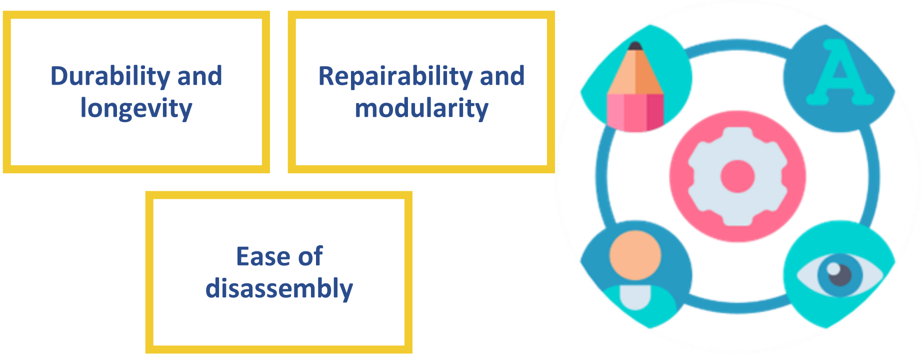

***Figure 45**. Key circular economy principles emphasised during the prototyping.*

Durability and longevity	**Repairability and modularity**	**Ease of disassembly**
Circular footwear design emphasises creating products that are built to last. Prototypes should be designed with a focus on durability, ensuring that they can withstand wear and tear over an extended lifespan. Materials chosen for the prototype should be high-quality and capable of maintaining their integrity over time, reducing the need for frequent replacements.	Prototypes should incorporate features that make repair and maintenance easier. This could involve using modular components that can be replaced individually without affecting the entire product.	Circular footwear design encourages products to be designed with end-of-life considerations in mind. Prototypes should be designed in a way that allows for easy disassembly into their constituent parts. This design approach supports efficient recycling and material recovery at the end of the product's lifecycle.

[42] Bouteille, R., Bakker, C., & Donke, T. (2020). Circular design strategies for footwear: A case study of sustainable sneakers. Sustainability, 12(19), 8054.

5.3. FOOTWEAR PRODUCT TESTING

Footwear testing involves subjecting prototypes to a variety of assessments to ensure they meet performance, comfort, and safety standards.

Footwear testing is carried out using a combination of standardized testing methods, industry-specific protocols, and in-house testing procedures. These tests help manufacturers identify potential design flaws, ensure compliance with regulations, and deliver high-quality products to consumers.

In the context of footwear design aligned with circular economy principles, the testing phase takes on added significance. Circular economy aims to reduce waste and promote resource efficiency, and testing plays a crucial role in ensuring that footwear products are not only functional but also sustainable throughout their lifecycle. To evaluate the alignment of footwear with circular economy principles, several aspects should be tested (Figure 46).

FUNCTIONALITY	MATERIAL PERFORMANCE	COMFORT	DURABILITY

Figure 46. *Main aspects of footwear testing in context of circular economy.*

Functional testing (wear, flexibility, impact, abrasion, water resistance, breathability, sole adhesion) evaluates how well the footwear performs its intended function, such as running, walking, or providing support. Circular economy emphasises designing products that have a longer lifespan and can be used for extended periods. Functional testing assesses how well the footwear performs its intended function over time. For example, testing how well the midsole retains its cushioning properties after numerous wear cycles helps ensure that the footwear remains comfortable and functional throughout its life, reducing the need for frequent replacements.

Figure 47. *Footwear performance. Source: https://www.blcleathertech.com/news/footwear-testing*

Material performance testing (Figure 48) includes assessing factors like flexibility, strength, comfort, and response to different environmental conditions. For example, if a footwear design incorporates recycled materials, designers need to test whether these materials maintain their integrity and performance characteristics.

Figure 48. *Leather test - Physical leather test. Source: https://www.ctcgroupe.com/en/about-ctc/values-57-1.html*

Comfort testing assesses the comfort levels of the footwear, considering factors like cushioning, fit, and breathability (Figure 49). Comfort is a key factor in prolonging the use of footwear. Circular economy principles encourage designing products that users enjoy wearing for an extended period. Comfort testing goes beyond initial fit assessments to evaluate how well the footwear maintains its comfort over time. By ensuring that the materials remain comfortable and do not degrade quickly, designers can contribute to the footwear's longevity and user satisfaction.[43]

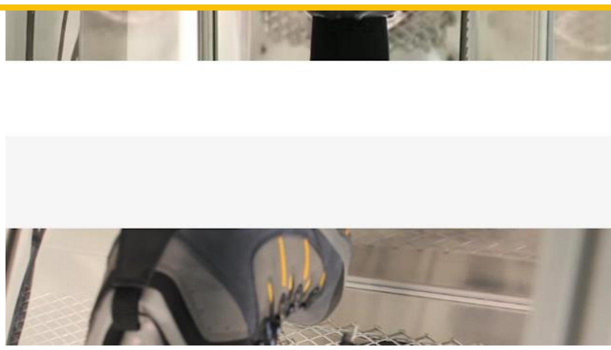

Figure 49. *Footwear breathability testing. Source: https://www.satra.com/footwear/performance.php*

Figure 50. *Footwear durability testing. Source:* https://pfi.hk/resources/an-overview-of-various-test-methods-of-flexing-durability-for-footwear/

Durability testing (Figure 50) simulates wear and tear to assess the longevity of the footwear under real-world conditions. Durability testing is essential in circular economy-oriented footwear design. Simulating wear and tear through rigorous testing can reveal potential weak points and areas prone to early deterioration. By identifying these vulnerabilities and reinforcing or redesigning accordingly, designers can create footwear that lasts longer and contributes to the reduction of waste by minimising premature disposal.

[43] SciLED project. (2021). Footwear in the 21st century. New skills for the scientifically-led design of comfortable, sustainable and fashion-oriented footwear products, 601137-EPP-1-2018-1-RO-EPPKA2-KA. Retrieved from https://sciled.eu/

Incorporating circular economy principles into footwear testing means not only evaluating performance but also assessing how the design choices impact resource efficiency, user satisfaction, and the product's overall environmental footprint. By considering the durability, comfort, and safety of footwear throughout its lifecycle, designers can contribute to the creation of products that are not only functional but also sustainable and aligned with circular economy goals.

5.4. FOOTWEAR PRODUCT ANALYSIS

After testing, the data collected is analysed to understand how the footwear performs under different conditions. This analysis provides insights into areas that require improvement or modification.

In the context of designing footwear with a focus on the circular economy, the analysis phase plays a crucial role in not only ensuring performance and functionality but also aligning with sustainable principles.

Functionally, aesthetically, and expressively analysis (FEE)

Functionally (F), aesthetically (E), and expressively (E) analysis is a structured approach used in product development and design to assess various dimensions of a product's qualities and attributes. Each of these dimensions - functionality, aesthetics, and expressiveness - represents a different aspect of how a product meets user needs and expectations. This analysis pattern is commonly used in footwear design, and consumer product development to ensure that the final product aligns with user preferences and requirements[44].

FUNCTIONALITY

Functionality (Figure 51) refers to how well a product performs its intended purpose and meets the functional requirements of users. In the context of footwear, functional analysis involves evaluating aspects such as comfort, fit, support, durability, safety, and any special features or technologies incorporated into the design. The aim is to ensure that the footwear functions effectively and provides the necessary features that users expect for their intended use.

Figure 51. *Functional considerations of FEE analysis.*

[44] Stokes, Bailey & Black, Catherine. (2012). Application of the Functional, Expressive and Aesthetic Consumer Needs Model: Assessing the clothing needs of adolescent girls with disabilities. International Journal of Fashion Design, Technology and Education. 5. 1-8. 10.1080/17543266.2012.700735.

In the context of footwear design and circular economy principles, tools such as **Finite Element Analysis (FEA)** can play a significant role in evaluating the structural integrity, material behaviour, and overall performance of prototypes (Figure 52). FEA involves utilising computer simulations to model and predict how various footwear components respond to different stresses, loads, and conditions. For circular economy-oriented design, FEA can help optimise the structural aspects of footwear, ensuring that the design withstands the rigors of use and aligns with durability goals. By virtually testing different materials and design configurations, designers can refine the structure for enhanced performance and longevity.

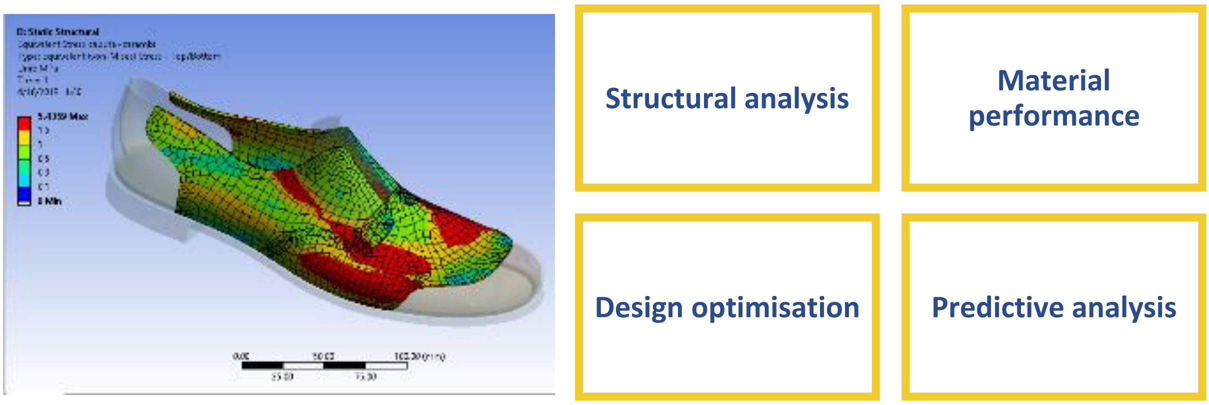

Figure 52. *Role of Finite Element Analysis as a tool for footwear product analysis. Credit: TUIASI*

A combination of physical testing and FEA analyses provides a comprehensive understanding of a product's functionality, performance, environmental impact, and alignment with circular economy principles.

AESTHETICS

Aesthetics (Figure 53) relate to the visual and sensory aspects of a product's design. Aesthetic analysis involves assessing the overall visual appeal, style, colour scheme, proportions, and design elements of the product. In the case of footwear, aesthetic considerations encompass factors like the design's visual coherence, alignment with current trends, and the emotional response elicited from potential consumers based on its appearance.

Figure 53. *Aesthetic considerations of FEE analysis.*

EXPRESSIVENESS

Expressiveness (Figure 54) involves the communication of deeper meanings, emotions, and brand identity through the product's design. In the context of footwear, it goes beyond mere aesthetics to capture the essence of the brand's values, identity, and the emotions it aims to evoke in consumers. Expressive analysis considers how well the footwear design reflects the intended message, personality, and cultural associations of the brand.

***Figure 54**. Expressiveness considerations of FEE analysis.*

Comprehensive product analysis

Footwear design process involves several crucial stages to refine and select concepts that are aligned with design specifications, followed by a comprehensive analysis to make informed decisions for further development.

Portfolio analysis

After the creative phase, where various design ideas are generated, a prepared portfolio is compiled. This portfolio typically includes a range of visual representations, such as drawings, sketches, mock-ups, and prototypes of different footwear concepts. These concepts are the result of creative brainstorming and exploration. The purpose of this stage is to critically evaluate the concepts and select those that best match the initial design specifications.

Selection of concepts

In this stage, designers and decision-makers review the concepts within the prepared portfolio. The analysis involves assessing how well each concept aligns with the established design goals, target audience preferences, and market trends. Concepts that effectively fulfil these criteria are chosen to proceed to the next stages of development. This selection process ensures that only the most promising and relevant ideas move forward, streamlining the design process and resource allocation.

Technological analysis

This involves evaluating the feasibility of turning the chosen concepts into actual footwear products. It considers factors like materials, production techniques, manufacturing processes, and any technological innovations required to bring the designs to life. This step ensures that the selected concepts can be produced using available resources and technologies.

Financial analysis

Assessing the financial aspects involves estimating the costs associated with producing the chosen concepts at scale. This includes material costs, labour, manufacturing overheads, and any other relevant expenses. Financial analysis helps ensure that the designs are financially viable and align with the company's budget and pricing strategy.

Marketing analysis

This step involves evaluating how well the selected concepts fit within the broader market landscape. It considers factors such as current trends, consumer preferences, competition, and potential demand. Marketing analysis ensures that the designs have a market fit and can effectively attract and resonate with the intended target audience.

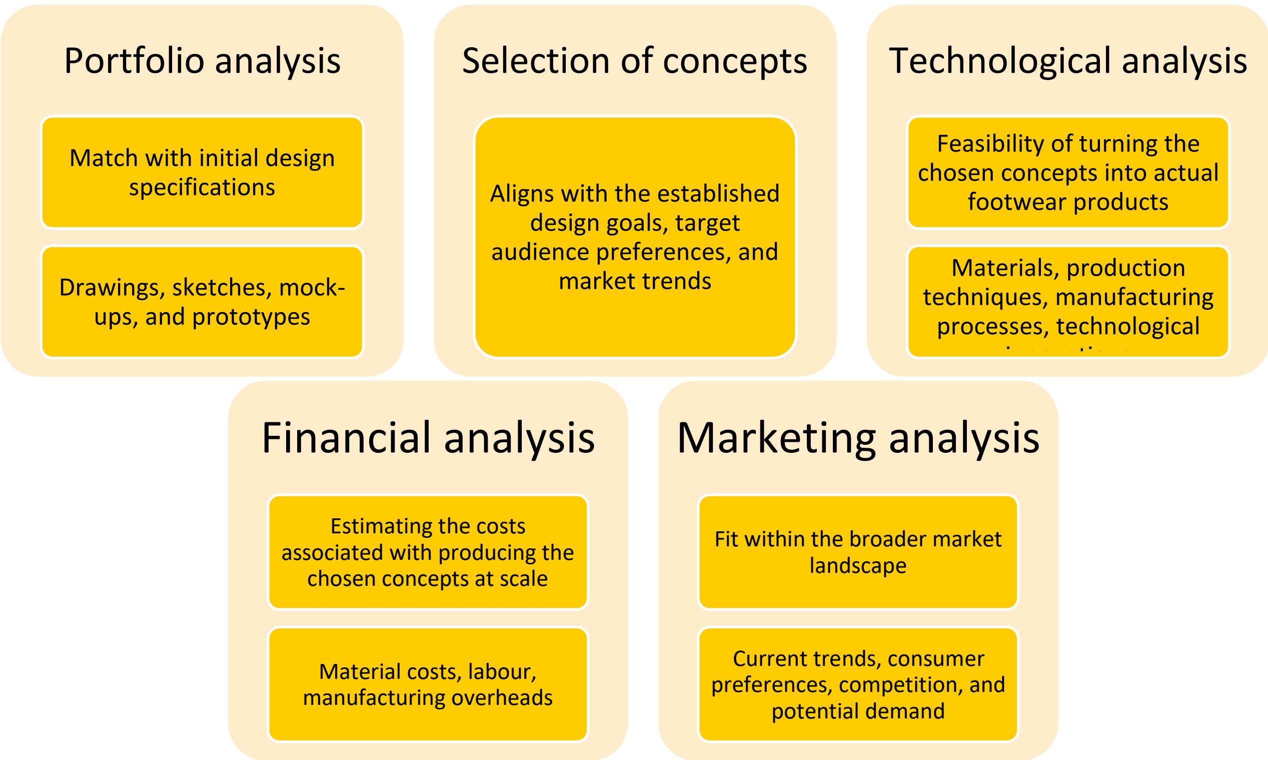

Figure 55. *Comprehensive product analysis.*

Circular economy principles integrated into testing and analysis stages

Incorporating circular economy principles into testing and analysis stages involves evaluating prototypes with a specific focus on their alignment with sustainability goals. Circular economy emphasizes minimizing waste and maximizing the value of resources over the entire lifecycle of a product. Therefore, during testing and analysis, designers assess how well prototypes align with principles such as repairability, reusability, and recyclability.

Assessing the potential for materials and components to be recycled

During testing and analysis, designers evaluate whether the materials used in the prototype can be efficiently recycled. This involves understanding the characteristics of each material and how they can be processed for recycling or repurposing at the end of the product's life. Materials that can be easily separated and recycled without significant degradation are favoured, as they contribute to a closed-loop system where resources can be continuously used.

For instance, designers might assess whether the footwear prototype is made from materials that are compatible with existing recycling streams or whether they require specialised processes. This evaluation guides design decisions to select materials that support the circular economy's goal of resource efficiency[45].

Figure 56. Adidas- Made to be remade shoes. Source: https://news.adidas.com/running/ultraboost-dna-loop-launches-to-public-as--made-to-be-remade--running-shoes-come-to-creators-club-we/s/38b4b53e-2343-4d9a-9c59-20feda458e2b

Evaluating the ease of repair and disassembly

Designing prototypes that are easily repairable and disassembled is a key aspect of circular footwear design. During testing and analysis, designers assess how well the prototype supports repair activities and how feasible it is to disassemble the product into its constituent parts. This evaluation ensures that when the product eventually requires repair, maintenance, or end-of-life processing, it can be done efficiently[46].

For example, designers might test whether fasteners are accessible and easy to remove, whether adhesives used in the prototype can be unfastened without damaging the components, and whether the design includes standardised connectors that facilitate replacement of specific parts.

Estimating the product's overall lifespan

Circular economy principles encourage extending the lifespan of products to minimize the need for frequent replacements. During testing and analysis, designers estimate the expected overall lifespan of the prototype based on factors such as material durability, construction methods, and potential for repair. This estimation helps in understanding the longevity of the product and its potential to contribute positively to the circular economy by reducing consumption and waste.

[45] Mederle, K., Katschnig, J., & Braun, A. K. (2020). Circular design strategies for closed-loop product systems: A case study on recyclable footwear. Resources, Conservation and Recycling, 158, 104807.

[46] Yu Fan Su, Robles, F. (2022). Sustainable circular shoe design: a footwear industry example of circular economy.

For instance, to comprehensively assess the environmental impact of the footwear, a Life Cycle Assessment (LCA) is conducted (Figure 57). LCA evaluates the product's environmental footprint from raw material extraction to disposal, taking into account factors such as energy consumption, emissions, and resource use at every stage of the product's life. This analysis guides the selection of materials, design decisions, and end-of-life strategies, ensuring that the product aligns with sustainability goals and contributes to a more circular economy[47].

***Figure 57.** Life cycle assessment methodology.*
Source: https://pre-sustainability.com/articles/life-cycle-assessment-lca-basics/

Incorporating these circular economy principles into testing and analysis ensures that designers are actively considering the lifecycle of the product and its impact on the environment. By making design decisions that prioritise recyclability, repairability, and longevity, designers contribute to a more sustainable and resource-efficient footwear industry.

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[47] Golsteijn L. (2022), Life Cycle Assessment (LCA) explained. Retrieved from https://pre-sustainability.com/articles/life-cycle-assessment-lca-basics/

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MODULE 4
SUSTAINABLE PRACTICES IN FOOTWEAR MANUFACTURING

BY **RUI MOREIRA** AND **RITA SOUTO**
CENTRO TECNOLOGICO DE CALCADO DE PORTUGAL

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

LECTURE 1
OVERVIEW ON THE TRADITIONAL FOOTWEAR MANUFACTURING PROCESSES AND RELATED MACHINERY

1.1. INTRODUCTION

The Footwear industry is seen as one of the most traditional sectors of activity in almost all countries where it's implemented. In Europe, it is responsible for an important volume of employment. Although is a labour-intensive industry, the improvement of the production process technologies is increasing. This lesson is focused on the traditional footwear manufacturing processes involving the organizational structure and the manufacturing process flow from cutting, stitching, assembly to finishing.

1.2. MANUFACTURING ORGANIZATION AND PROCESS FLOW

Functional organisation of a footwear company

A typical function organization chart of a footwear factory includes, usually includes, at the top, the administrator or the top manager, and at the level immediately below, the managers of the main departments, such as administrative, financial, commercial, production, planning and purchasing, quality.

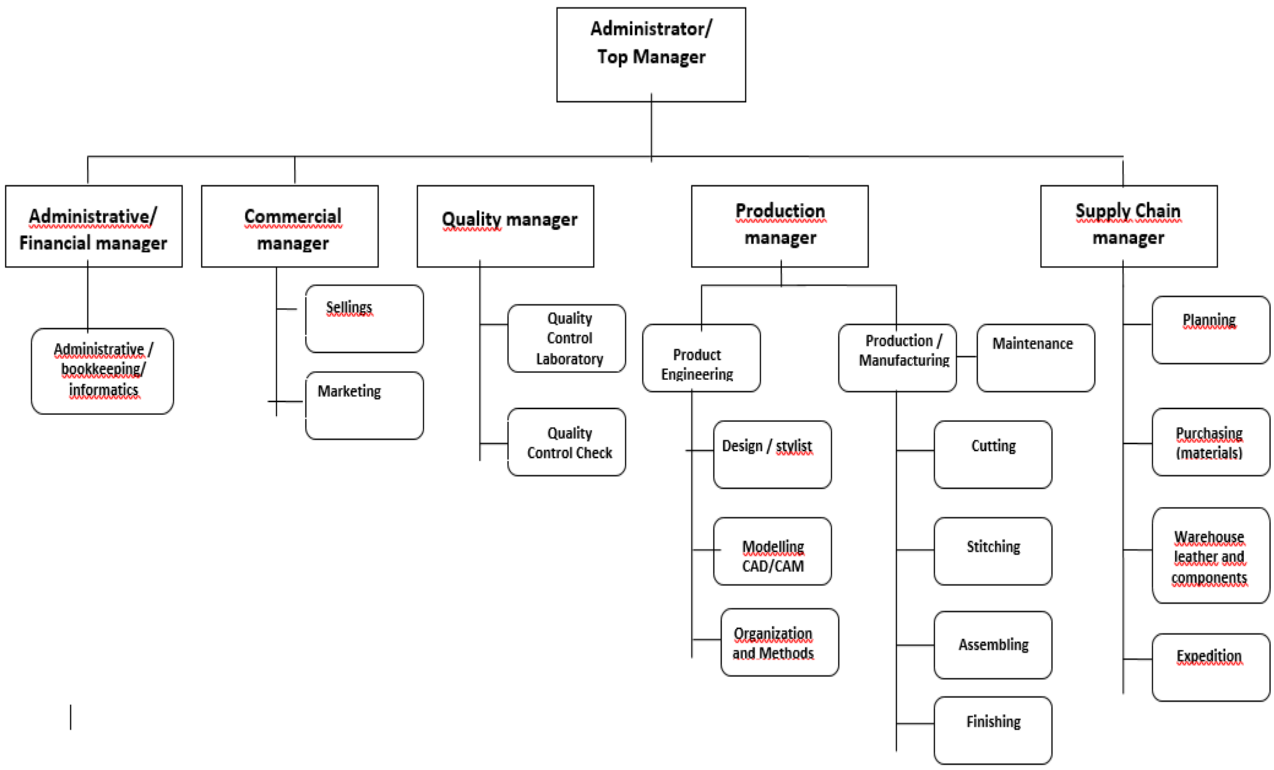

Figure 1. *A typical function organisation chart**.** Source: CTCP*

Footwear manufacturing process

The footwear manufacturing process includes a sequence of operations that are normally associated with the main departments, that are the warehouse, where is done the reception and control of raw materials, the cutting department, the pre-stitching department, the stitching department, the pre-assembling department, the assembling department, the finishing and packing department and the expedition area.

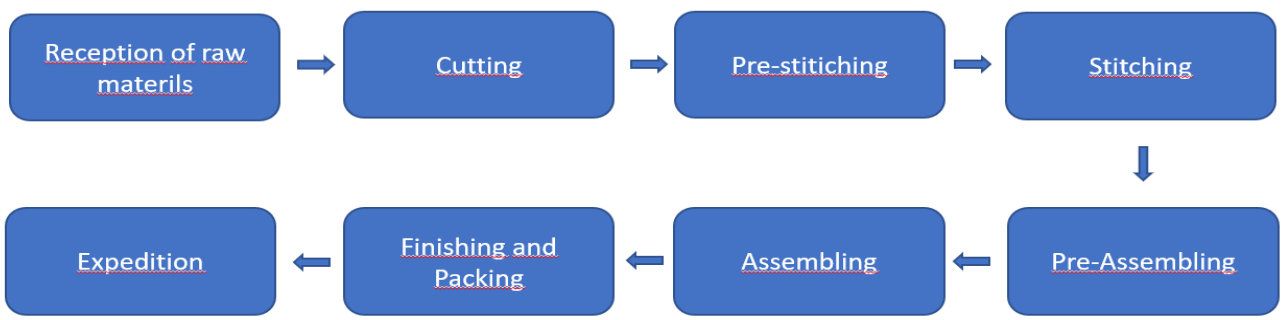

Figure 2*. Sequence of operations of the footwear manufacturing process**.** Source: CTCP*

The manufacturing process starts off with the cutting of the materials. Using cutting dies to cut each necessary section of fabric or leather manually or using a clicking machine or even through an automatic cutting system connected to the CAD in technical development.
Then comes the pre- stitching – which involves several operations to prepare the cut components for making the upper such as splitting, fabric attaching, ironing, stamping, skiving, folding, crimping etc. Fabric attaching, taping at the edge of components make that strengthen. Skiving is for tapering the edge and crimping is for 3D shape. Screen printing and embossing are also part of this stage.
In many processes these operations are distributed within the cutting department and stitching department. Then comes the Stitching department where components are joined together, the lining is attached to make the upper. The upper then follows to the assembly department.

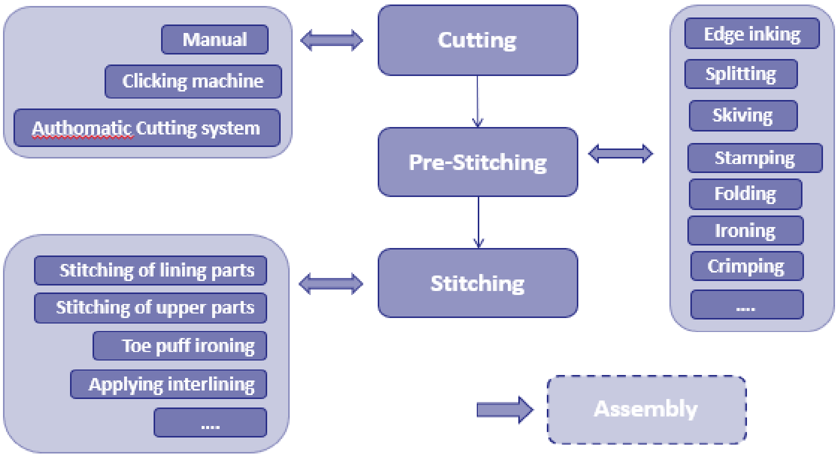

Figure 3. *Manufacturing process**.** Source: CTCP*

The finishing department is divided into two main phases: the finishing operations and the expedition where the order is delivered to the client.

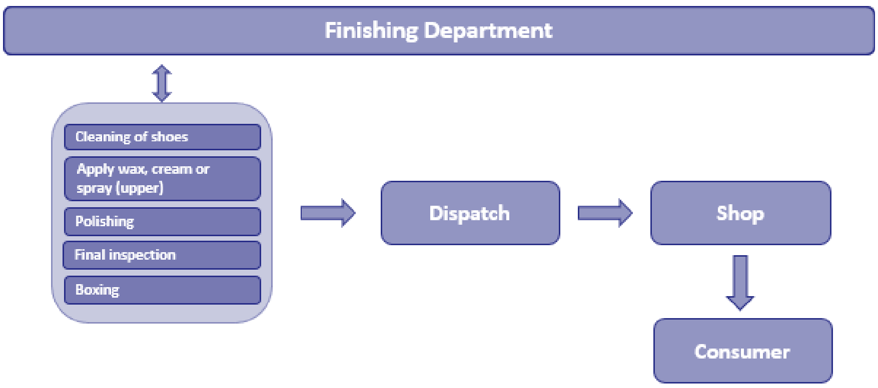

Figure 4. *Manufacturing process – finishing department**.** Source: CTCP*

In the modern industry the process is divided into many and distinct stages as product engineering, warehouse, cutting, pre-stitching, stitching, pre-assembling, assembling, finishing and packing, expedition. Initially employees made the shoes from the beginning to the end, but in the modern industry the process is divided into many and distinct stages as:

- Product engineering: creation, elaboration and accompaniment of the models in the manufacture process;
- Warehouse: act of receiving, storage, classification and control of the leather and other materials;
- Cutting: cutting operation of the different parts that compose the upper part of the footwear.
- Pre-stitching: preparation of cut pieces to receive the stitching;
- Stitching: junction of the parts that compose the upper part of the footwear.
- Pre-Assembling: preparation of stitched pieces and soles to the assembling operations;
- Assembling: set of operations that join the upper part of the footwear with the sole;
- Finishing and Packing: final operations linked to the presentation of the footwear as brushing, painting and cleaning;
- Expedition: packing, boxing and sending to the destination market.

1.3. TRADITIONAL TECHNOLOGIES FROM CUTTING TO FINISHING

Cutting

The operation of cutting leather or other materials can be performed either manually or mechanically. Traditionally the cutting operation began to be made by hand, but nowadays a large part of the footwear companies uses equipment to do it, either the traditional clicking machines or even the automatic machines, which use CNC processes to carry out the operation.

In most of the footwear manufacturing processes a cutting press is used, which can be swing arm (more used for leather) or bridge (most used for synthetics). To use this equipment, it is necessary to pre-execute the collection of cutting dies, based on the carton moulds made for each model in the product development department, whose cost then must be compensated by the decrease of the operation time and the economy of labour.

Figure 5. *Different models of Hydraulic cutting machines. Source: CTCP*

Stitching

Stitching is the most economical and versatile way to combine elements of uppers, preserving the high quality of the product, which allows to perform the most complex designs, providing an additional aesthetic value. The versatility of this method lies in the possibility to apply it to all materials, whether they are leather, fabrics and artificial leather, and all models of shoes.

For centuries, shoes were made entirely through stitching techniques. Currently stitching is dominated by assembly processes and is mainly restricted to the production of uppers.

Currently stitching of footwear is performed by various types of stitching machines. Manual stitching is generally auxiliary and is mostly used for different types of decorations.

Within the process of stitching, the following concepts are inextricably linked: stitches and seams sewn, needles and thread, stitching machines and stitching parameters.

Figure 6. *Stitching machine head.*

Table 1. *Stitching parameters*

Stitching parameters
Stitches and seams sewn
Needles and thread
Stitching machines

The most used technology in stitching are the stitching machines. There are diferent types of stitching machines, used according to the operation, the material, product.

Figure 7. *Different types of stitching machines. On the left the flat-bed stitching machine. On the right the pillar stitching machine*

Flat stitching machines are used for stitching some certain components of the shoe uppers, not requiring emphasizing its shape. Most often they use it to joins lining sewn noses on the vamp on toe, facing, foxing.

Cylinder-arm stitching machines are designed to perform the convex curved seams on the elements combined, which is difficult to access. These machines are manufactured as: left arm, right arm, and the arm directed to the worker. The construction of machines provides solutions both multi-needle and is adjusted, inter alia, to combine vamps, stitching on toes and performing decorative seams.

Pillar machines - They allow you to match the pieces of the shoe upper in places hard to reach. By attaching the hook mechanism and the conveyor material on the elevated post, it is possible to combine the elements/pieces of complex shapes and cuts. Raising the plane in which are the parts to be joined, in relation to the worktable of the machine, gives the possibility of "entering" in one of the materials.

Figure 8. *Different types of stitching machines. On the left the flat-bed stitching machine. On the middle cylinder-arm stitching machine. On the right the pillar stitching machine*

Assembling

Assembly is one of the most complex phases of footwear. Traditionally the assembly operations were completely artisanal and manually executed but actually most of the shoes produced are made using a cemented construction system supported in specific machines. These processes are accompanied by technological procedures which are related to: upper and bottom parts assembly on last, stabilization shapes of the upper, cementing preparation, attaching uper and bottom parts, delast and storage lasts. There are other construction systems like, for example, strobel, Pratik and goodyear. Globally the nature of these construction systems is usually determined by mounting system on the last and cementing techniques.

Assembly involves several operations to assure the attaching of upper and bottom.

There are several systems of shoe assembly but the most used is cemented construction used in the majority of shoes produced all over the world. This construction process is based on the artisanal process based in manual tools, cement and nails.

Lasting is a process of conversion of the planar upper to three-dimensional shape determined by the shape of the last, which performs this operation. The development process of lasting was continued for decades. Initially shoes was lasting by hand using simple tools. When tensioning uppers used a special tong and rolled edges of the upper nailed to the insole by tacks. As technology progressed, the first machine, which facilitated the process of nailing the individual parts of the uppers. Began to appear new systems of lasting. The most widespread system was multioperations. Gradually a three-operations and double-operatios systems. Important in the process of lasting was the replacement of rigid connectors (texts, clips) by new generation of adhesives that are automatically applied directly to the connected elements.

Figure 9. *Assembly by hand, by machine, assembly cemented construction*

Assembling – cemented system

The principle of lasting is bring the upper to the shape of the last, plastic tool designed and developed in accordance with pedologic parameters and fashion, and to connect upper and bottom. In cemented construction the upper is forced over the last by stretching the upper materials (leather or other), operation made in two parts: First, the toe lasting - machine lasting top, sides and forefoot.

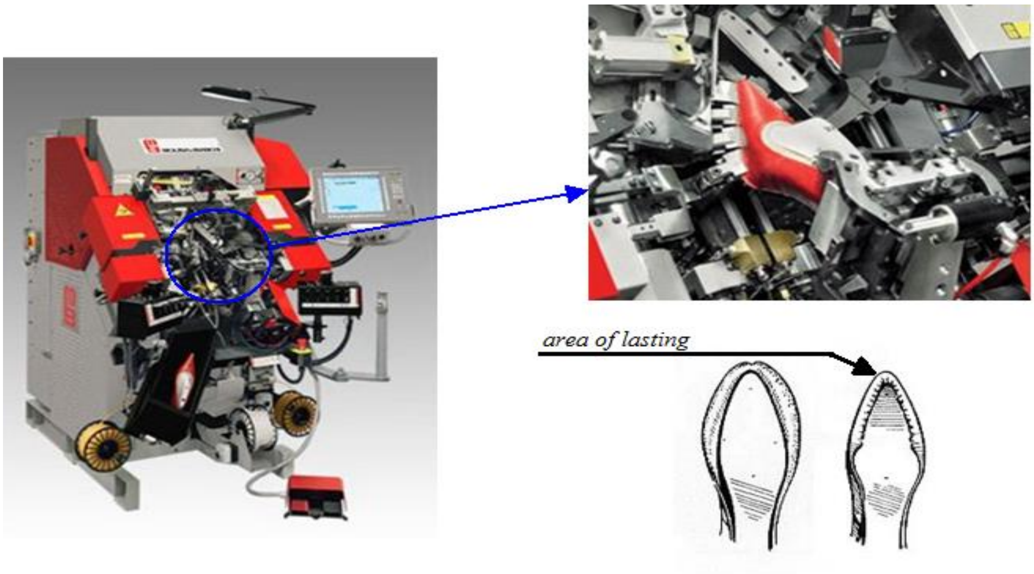

Figure 10. *Lasting foreparts*

The second part of the process involves backparts and metatarsus. The whole cycle of lasting can be done with glue (usually thermoplastic) possibly some sections can be enhanced or lasting on tacks.

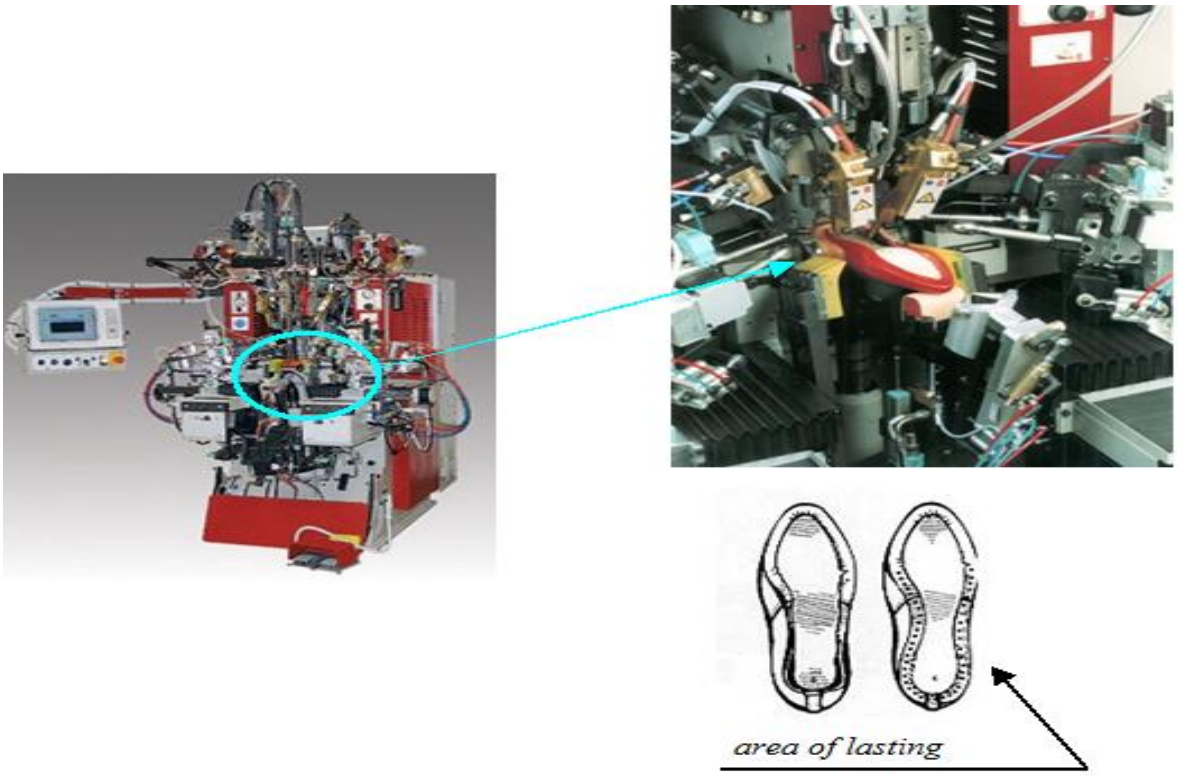

Figure 11. *Lasting backparts and sides*

Roughing and adhesive application

Roughing: Most often this operation is performed on special machines called roughing machines. Grinding tool are the most special shields, heads or abrasive cloth. Attrition is to remove exterior structure of the skin,. This factor determines the strength and durability of glued connection.

Applying adhesive – this operation is frequently made manually although there are already CNC machines to provide this operation mainly in flat assembled uppers. The adhesives must dryand be reactivated before next operation

Figure 12. *Roughing and gluing*

Pressing the adhesion between soles and upper

Pressing- this operation completes the process of merging the upper with the bottom part of the shoe. In the process of pressing we observe the applicable parameters that result from the types of bonded materials and glues used. The basic parameters include amount of pressure and pressing time.

Figure 13. *Pressing operation*

Assembly – final operations

After pressing footwear translates into special devices called colloquially coolers, which are made to lower the temperature of shoes after the thermal activation of adhesive and the compacting process.

The process of stabilization aims at consolidating the shape of the shoe uppers granted by the last in the process of lasting. Lasts can be slipped manually on special racks or using last puller. The shoe follows for finishing operations or, in depending on the product, to other specific operations made before finishing, like lateral stitching (used frequently in sneakers) and heel attaching (used in high heel shoes).

Figure 14. *On the left Machine for stabilizing footwear (low temperature); on the right Last slipping machine*

Figure 15. *On the left Stabilize shoe; on the right Sslip the last on Last slipping machine*

Finishing

There are several ways of finishing. The various types of finishing depend mainly on the type of materials used, the desired final appearance and the model configuration.

The same model may even have different finishes, depending on the type of leather used, thus giving rise to a variety of Finishing Types.

If through the finishing operations the product becomes more beautiful, attractive and with a softer touch, we can get the difference that makes selling the product.

Finishing involves the final operations of footwear manufacturing. **Finishing** is done with the aim of ensuring the best treatment on the surface of the shoe, improving the visual appearance of the product and making it more attractive, both visually and to the touch.

Figure 16. *Packing*

Types of finishing

The main **types of finishing** used in footwear are: waxy, oily, casein, polished and plasticized. In the images it is possible to see example of waxy finish, Oily finish and plasticized finish.

Waxy finish is the type of finish that requires more processes, because in this case the leather is more absorbent and rawer, as for example aniline and semi-aniline, and as they are not completely finished in tanning factory, require a final finishing in the shoe factory.

<u>Oily finish</u> is associated mainly with calf skin, where oil is applied during manufacture.

<u>Plasticized finish</u> is associated with patent leathers that have a surface coating of PVC or polyurethane to give a very high gloss finish. The treatment is used for high fashion footwear, but has the disadvantage of reducing the ability of leather to breathe and release perspiration

Figure 17. *On the left Waxy finish; on the right Oily finish*

Figure 18. *Plasticized finish*

Technology of finishing

Finishing process is very much supported in manual operations like cleaning, insole application, laces and labels. The technologies used in finishing operations are usually brushes and painting booths. The brushes are very important in the finish process as they have functions as polishing, smoothness, brightness and removal of excess of finishing products. Rotating machines, with manual speed selector, are the most suitable because they allow control of the speed, which is very important for obtaining the best results.

Painting booths are usually used to make the finishing more efficient and secure for the worker. It is recommended to use compressed air guns in the paint booth for applying finish bases, applications of brightness, oils, inks for color correction and color enhancers. The pistols have the advantage of uniformity of application and must have pressure control and always be well cleaned.

Figure 19. *On the left Brushing the shoe; on the Painting the shoe*

LECTURE 2
NEW MANUFACTURING TECHNOLOGIES AND PROCESSES

2.1. INTRODUCTION

New technologies are being developed and are, many of them, already used on footwear manufacturing processes. Agility and productivity are the main objectives but also sustainability and the shortening of all the footwear manufacturing process from prototyping to expedition. I4.0 principles are essential to achieve the best integration of information with manufacturing technologies and processes.
Although is still a labour-intensive industry, the improvement of the production process technologies is increasing. New technologies are used from design, prototyping to cutting, stitching, assembly, and finishing. It is expected to reduce the dependence on labour and operational skills and with that to have manufacturing and consumer closer. New manufacturing technologies search for agility and productivity, that means to produce diversity of products with short lead times and high productivity.

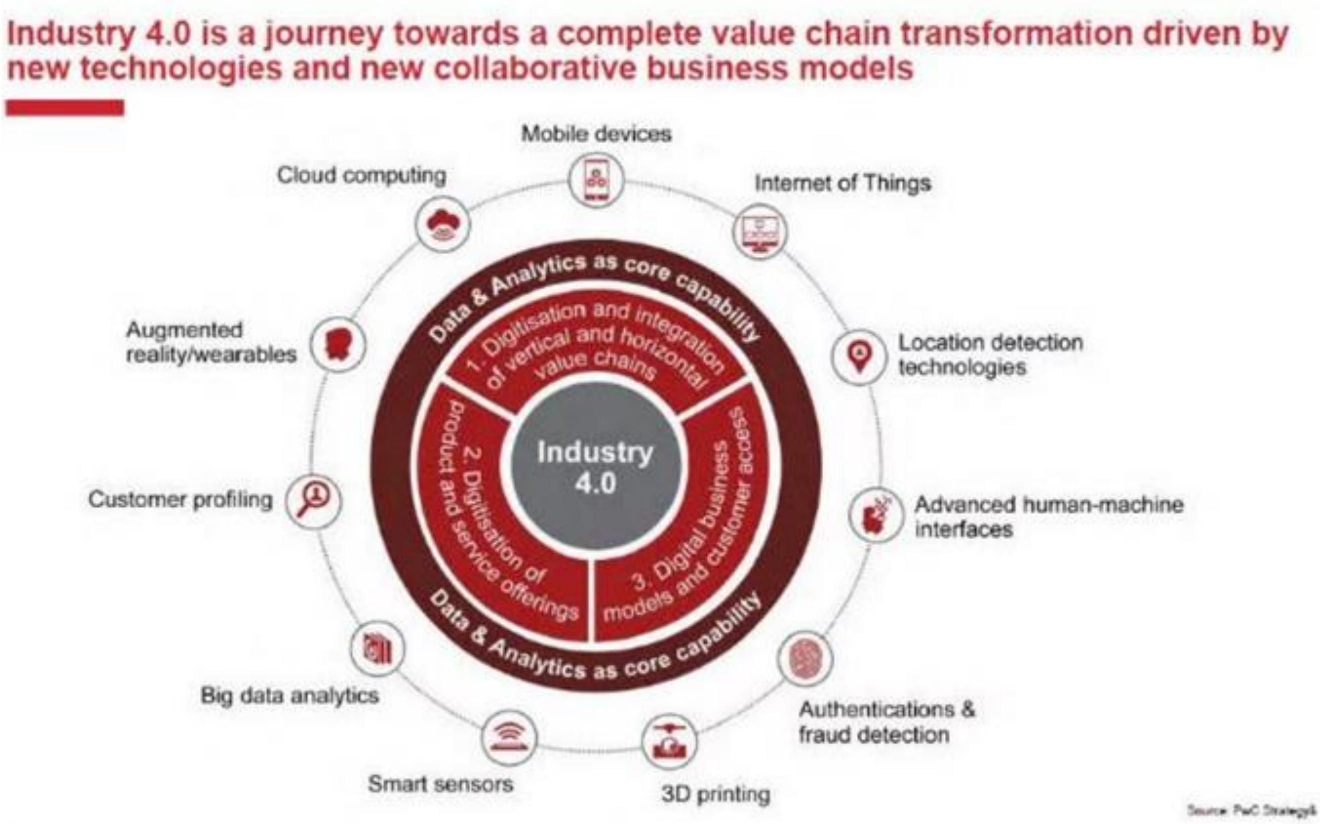

Figure 20. *i4.0 scheme**.** Source: PwC*

The main pillars supporting i4.0 are:

- Cyber-physical systems (CPS) connecting the physical and virtual worlds, such as the physical shop floor and the computational virtual space, allowing real time management of autonomous production processes.
- Internet of things (IoT) inter-connecting machines with embedded electronics, sensors, actuators, and network connectivity allowing these devices to collect and exchange data.
- Internet of services (IoS) letting companies offer their services online, such as, but not limited to, virtual showrooms and design based on augmented reality.

Nowadays, shoe industry may be considered almost all over the world one of the most developed industries concerning the technological content. New technologies and processes are being developed and used in different domains, since prototyping, cutting, stitching and assembly.

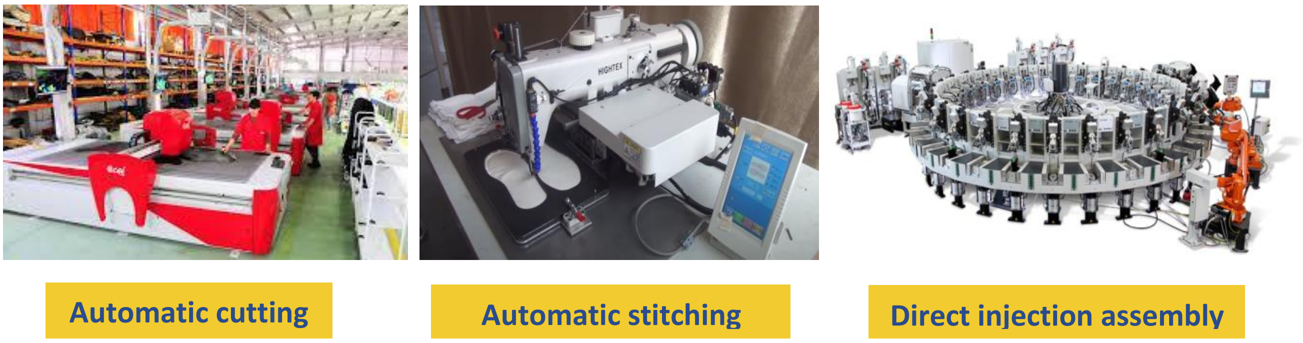

Figure 21. *Automatic cutting, automatic stitching, direct injection assembly*

2.2. INTEGRATING NEW SOLUTIONS AND TECHNOLOGIES IN FOOTWEAR PROCESSES

Nowadays, viewed as the fourth industrial revolution, it embodies the organization and production processes supporting the full digitalization of the manufacturing industries. Real time communication between devices is key, as well as between different factories, and companies and clients.
The implementation of the concepts of i4.0 will result in “smart factories”.

The use of new footwear manufacturing technologies and it`s integration with other digital systems will result in the implementation of “smart factories”.

Most technologies available for footwear industry can be included in the following groups: Cyber-physical Systems, automatization and robotic, Flexible manufacturing and customization, Footwear Sensorization, Virtual reality, 3D printing and digital prototyping, Co-design. IoT, Cloud computing.

Internet of things

Virtual reality

Co-design

3D printing / prototyping

Cyber-physical Systems, automatization and Robotic

Flexible Manufacturing and Customization

Footwear Sensorization

Virtual reality

Figure 22. *Cobot. Source: CTCP*

The new footwear manufacturing technologies are now prepared to interact with other systems. Smart manufacturing — or the use of emerging, advanced technologies to increase the efficiency of traditional manufacturing processes — is creating a more agile and productive industrial base.

Figure 23. *Landscape of the footwear stitching manufacturing plant***.** *Source: CTCP*

Modern footwear manufacturing technologies are now available to support the gradual implementation of I4.0 concepts:

- Machine to machine communication for autonomous production allowing the use of advanced robotics;
- Advanced human-machine interface for collaboration between human and machines in a safe and productive environment;
- Data mining for the analysis of the large amount of data collected for advanced decision making based on real-time data and predictive analysis;
- Enterprise resource planning (ERP) and business intelligence based on interconnected and controlled production processes;
- Smart factories where everything is connected supported on CPS, IoT and cloud computing.

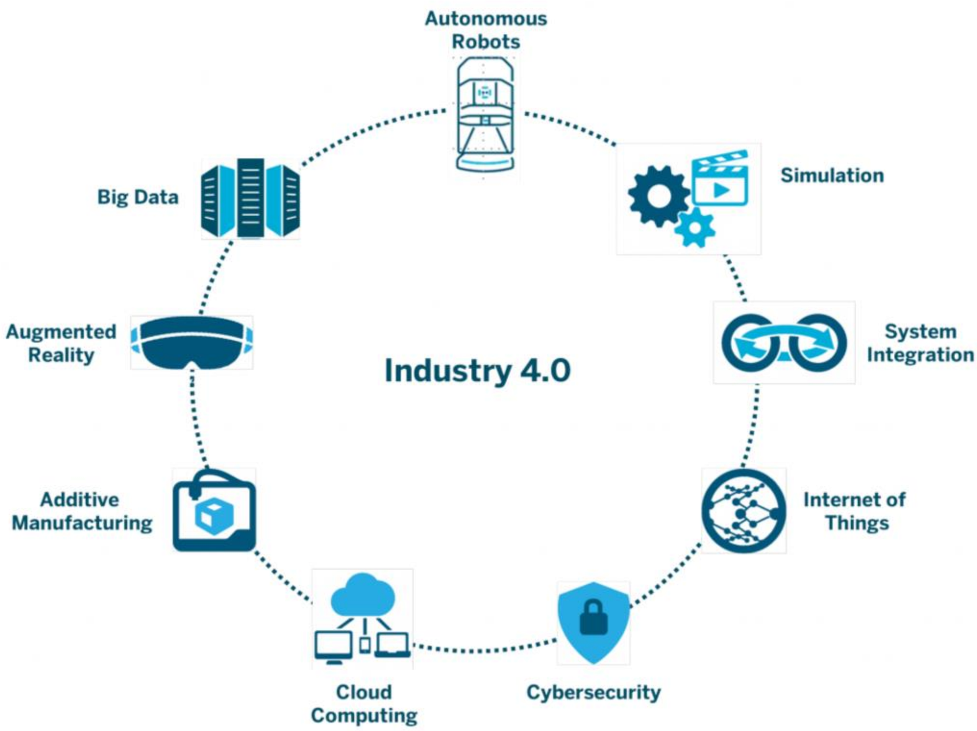

Figure 24. *i4.0 integrated systems.*
Source: https://medium.com/@billsoftnet/industry-4-0-and-manufacturing-processes-856567fcb59

2.3. NEW TECHNOLOGIES FROM PROTOTYPING, CUTTING TO FINISHING

Prototyping

Digital prototyping is a technology that permits to develop the first prototypes in a quick and feasible way avoiding the need, in many situations, to manufacture a physical prototype. There are several solutions in the market permitting afterwards the connection through CAD 3D to the industrial development of the product.

Figure 25. *Source: https://www.mindtech.pt/images/solutions/viewer/mindCAD-viewer.jpg*

Prototyping – Additive Manufacturing

Additive manufacturing or 3D printing is a new technology used in development of components for prototyping. The production of prototypes of pre moulded soles by 3D printing technology accelerates this process and avoids the cost of development and production of a first prototype mould. Actually, it is possible to produce soles in materials used in current production like TPU. Additive manufacturing can be used in other domains like, for instance, production of lasts for orthopaedic shoes.

Figure 26. *Printing a footwear sole. Source: CTCP*

Additive Manufacturing

It’s already possible to get a pair of 3D printed shoes made with a 3D printing technology. There are several brands focused essentially in the production of 3D printed footwear. This technology has limitations in the use of the more traditional footwear materials, but the use of different materials permit the development and production of customized shoes, besides the potential advantages in the use of principles of circular economy.

Figure 27. *3D printing pair of shoes.*

Automatic Cutting Machines – Semi automatic process

In the semi-automatic process, the placement of the model parts is performed virtually on top of the leather, after it has been placed in the cutting machine, and it is not necessary to digitize it previously. The cutting machine then allows the operator to project the parts onto the leather and place them in the places he finds most convenient. In the end it is enough to order the machine to cut. In this case the experience of the operator is decisive for the best use of the leather. At present, the most used automatic cutting machines have different processes for cutting the materials: by knife or by water jet.

Figure 28. *Automatic Cutting Machines – Semi automatic process*

Automatic Cutting Machines – Automatic process

In the fully automatic process, all the leathers that are to be cut are scanned, that is, its contour and type of defects is reproduced in the computer, the parts of the model are placed automatically and then it is just to put the leather in the cutting machine and start the cutting process. This process can also be used with other materials being simplified if the material is regular with no defects.

Figure 29. *Automatic Cutting Machines – fully automatic process*

Automatic Stitching Machines

Modern stitching machines can automatically perform tasks that are repetitive and that incorporate most of the time needed to produce a pair of uppers. Some benefits of using automatic sewing machines:

- For example, a worker can operate two sewing units at the same time, which is a great labor saving;
- Reproductive stitching process brings constant conformity;
- When used in long time traditional stitching operations can bring a significative reduction of time and costs;
- The formation of tight stitches in a constant and uniform way. We always obtain the same strength in the seam and the same appearance;

Figure 30. *Stitching Machines*

New upper processes – Knitted uppers

In recent years the use of new materials and processes permitted the development and production of new products. Knitted footwear started to be used in sports shoes and gradually was transferred to fashion shoes. The technology is based in loom machines adapted to produce uppers. In this way the traditional process of upper stitching can be reduced or even eliminated.

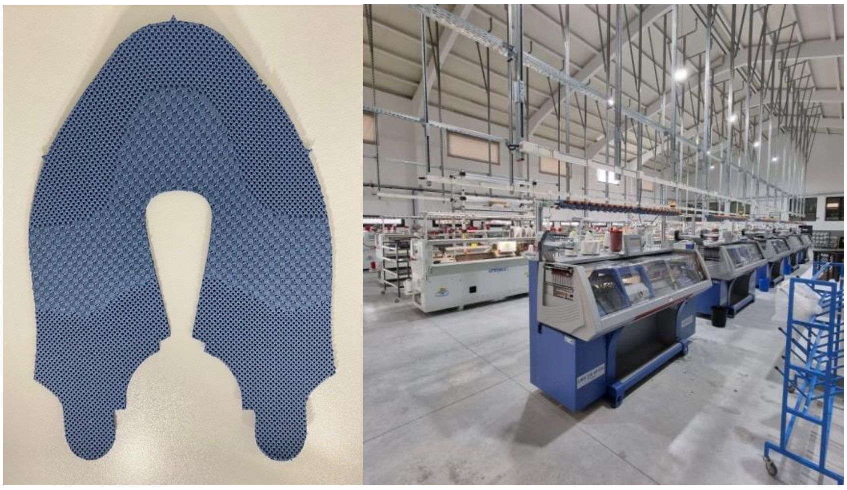

Figure 31. *Knitting technology*

Lasting technologies

The technique of double-lasting operation is used in cemented lasting system. New technologies have been developed in recent years with more flexible and productive machines processes. The developments are mainly dedicated to cemented lasting system. The lasting process made in two steps, is programable for different lasts assuring a quicker set up, when lasts are changed, and a lasting process less dependable from worker`s skills.

Figure 32. *Lasting machine*

Assembling technologies

Roughing and applying adhesive has a significant impact on the strength of the adhesive connection. New technologies include the use of CNC machines and robots to make these two operations. The advantage of this technique is cost-effective and uniform roughing and application of adhesive and the good anchoring at the surface of the materials to be bonded. When included in conveyors the use of robots can turn this process completely automatic without the need of skilled workers. More flexible, reproducible and productive process can be achieved in the adequate manufacturing process and product.

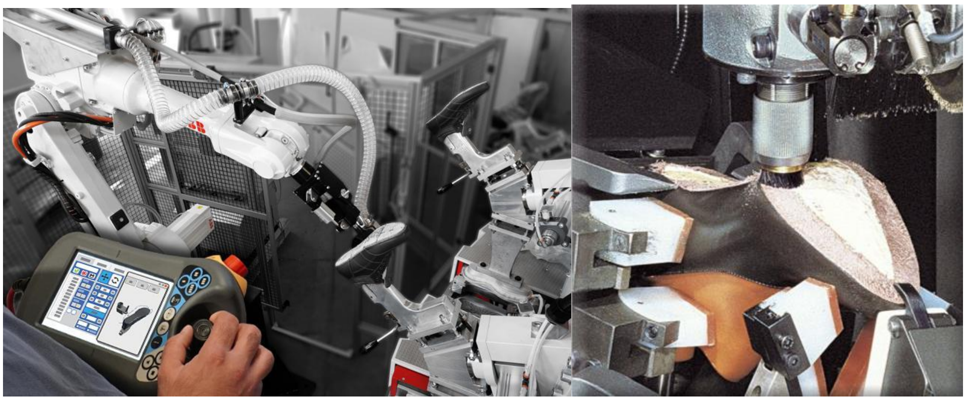

Figure 33. *Roughing and gluing*

Innovation and flexibility are being introduced in direct injection. In this process the upper is dressed in the aluminium last of the injection machine, and it is then submitted the TPR, PVC or PU direct injection. Recent new developments brought additional flexibility to this process with capacity of using different colours and densities and the capacity to match well with knitted uppers. This combination permits the production of footwear in a more capital-intensive way.

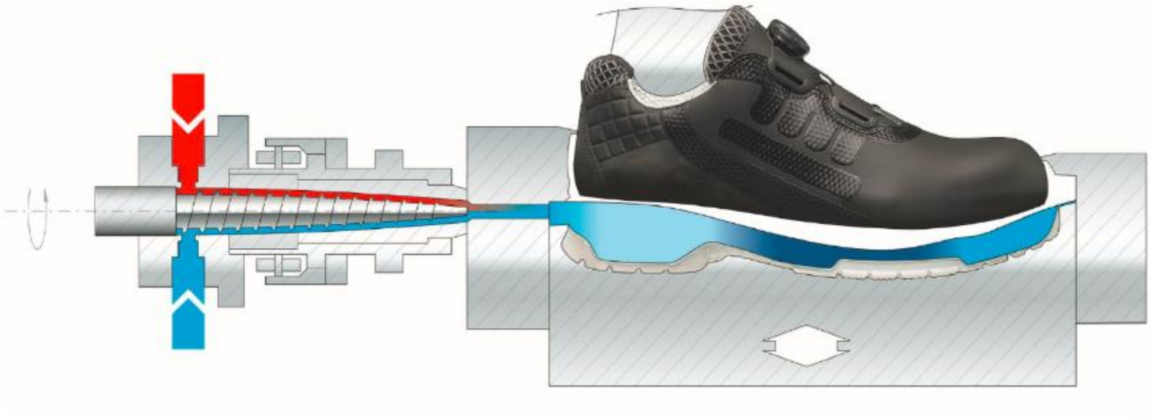

Figure 34. *Multi Section Injection. Light blue is more durable, dark blue is more flexible*

A molten material, normally a polymer, is forced into the cavity of a mould. This is managed because of the high speed and pressure making the material react and solidify directly in the mould. Normally, but depending on the material, a high mixing speed of the injection material results in a better grain structure and better physical properties. Normally the screw, controlling the mixing speed, in the injection process rotates at around 18000 rpm. When the material solidifies in the mould it takes the desired shape and is removed from the mould. In the footwear industry, focusing on assembled shoes, it´s commonly used in a “direct moulding on” process. With this, finished shoe uppers are firstly prepared by dressing a last mould. Surrounding this last mould another two-piece mould with cavity for the outsole is encapsulating the full upper. This two-piece mould includes an injection point where the molten material creating the outsole will be pushed through. When the material cools down it attaches to the upper creating a strong bond. Robots can be integrated in the process making it highly productive and less dependent on worker´s skills. It´s use is widespread in sports footwear, security footwear but also, each times more in casual footwear.

Figure 35. *Direct Injection production line*

LECTURE 3
AVAILABLE METHODS FOR IMPROVING THE ENVIRONMENTAL PERFORMANCE

3.1. INTRODUCTION

To reduce the environmental impact of a manufacturing footwear process should be one of the main objectives of a footwear company. This reduction can provide environmental benefits but also economic value for the company. A more sustainable footwear process implies to use less resources (energy, materials, labour) and to reduce waste, having the capacity to provide up-cycling solutions for its waste. Step by step companies must measure it´s environmental performance and implement systems, technologies, methods to improve and become a more environmentally sustainable company.

A manufacturing process with less environmental impact implies working:

- in an environment-friendly way, with less waste
- with environment-friendly materials
- with less resources / resource-saving processes

It means that during sustainable manufacturing it's used methods that allow to produce shoes in an environment-friendly way, with environment-friendly materials (such as biodegradable or recycled / recyclable materials), with less resources (in terms of operations, labour, materials, energy).

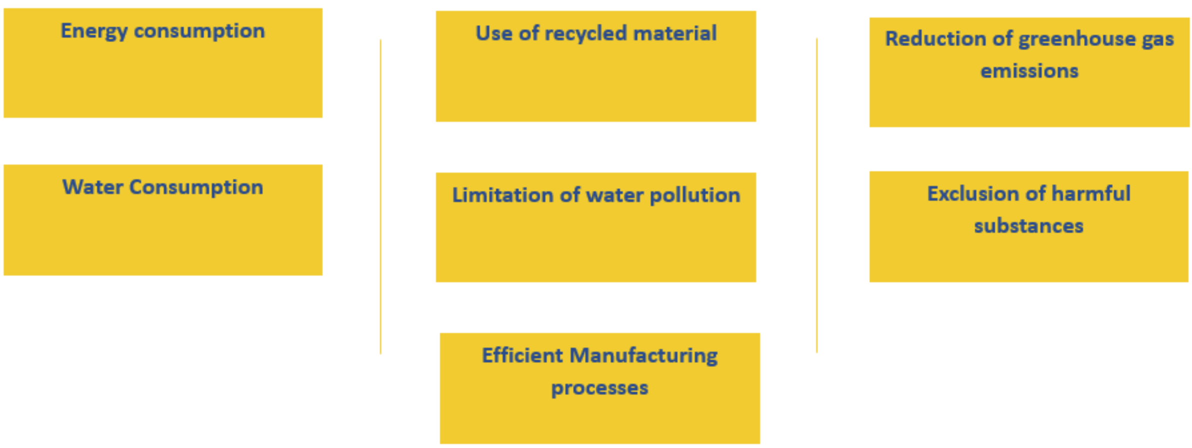

Figure 36. *Factors that lead to less environmental impact manufacturing. Source: CTCP*

What should be considered to meet an improved environmental manufacturing process?

To improve the environmental performance, it is important to consider:

- Energy consumption;
- Reduction of water consumption;

- Use of recycled material;
- Limitation of water pollution;
- Reduction of greenhouse gas emissions;
- Exclusion of the use of substances harmful for the health and the environment;
- Highly efficient manufacturing processes (lean processes)

These aspects are considered within the scope of an environmental management system but can also be identified and improved as part of a company sustainable strategy.

3.2. MEASURING ENVIRONMENTAL PERFORMANCE

Dashboards permit a visual analysis of Key performance indicators and are a useful support to identify deviations from the objectives and the areas of improvement with higher impact on environmental performance. Dashboards can also be useful to integrate and concentrate the analysis of different Key Performance indicators and identify the causes of the deviations from objectives.

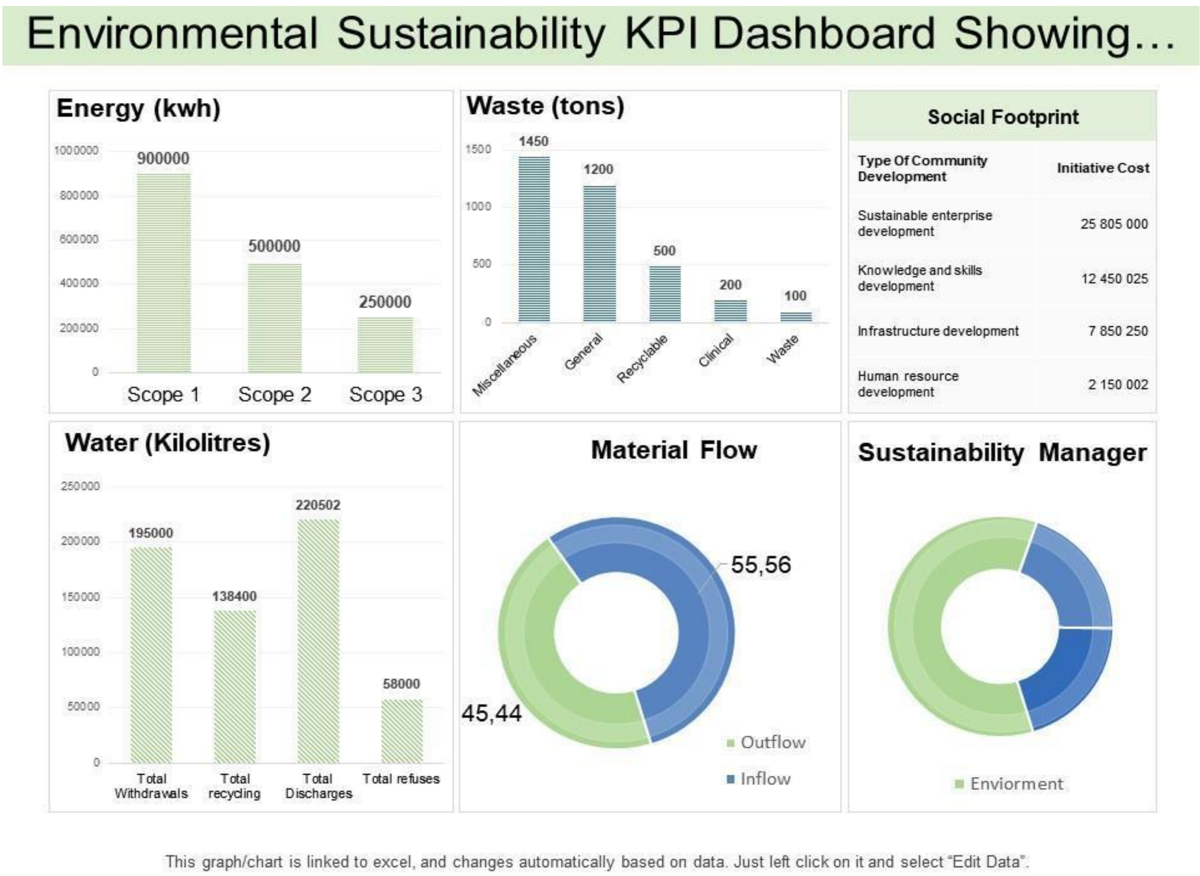

Figure 37. *Environmental Sustainability KPI Dashboard. Source: CTCP*

3.3. HOW TO IMPROVE ENVIRONMENTAL PERFORMANCE

One way to start is to implement an environmental management system in accordance with ISO 14001 standard. ISO 14001 is an international standard relevant to improve the environmental performance throughout the manufacturing processes. It starts with the identification of environmental risks within manufacturing process, selection of Key process indicators to measure environmental performance and definition of improvement objectives and correspondent actions.

Figure 38. *ISO 14001 dimensions. Source: https://www.mindtech.pt/images/solutions/viewer/mindCAD-viewer.jpg*

The footwear manufacturing process is complex with many materials and components integrated in a process usually intensive in labour. So planning is important and good line balancing is required for consequence in footwear´s operation to achieve higher productivity. To find out balance in productivity, utilization of line balancing operation is very much needed. Effective time in each operation cycle must be calculated in proper balanced line operation for better productivity. The following factors affect efficiency in footwear manufacturing but also its environmental performance:

- Proper planning with product category style.
- Properly materials choice and utilization with changing style.
- Manpower utilization with targeted time to fulfil requirement of production.
- Proper utilization of machineries.
- To make over the product price utility.
- Management organization with adequate information flow

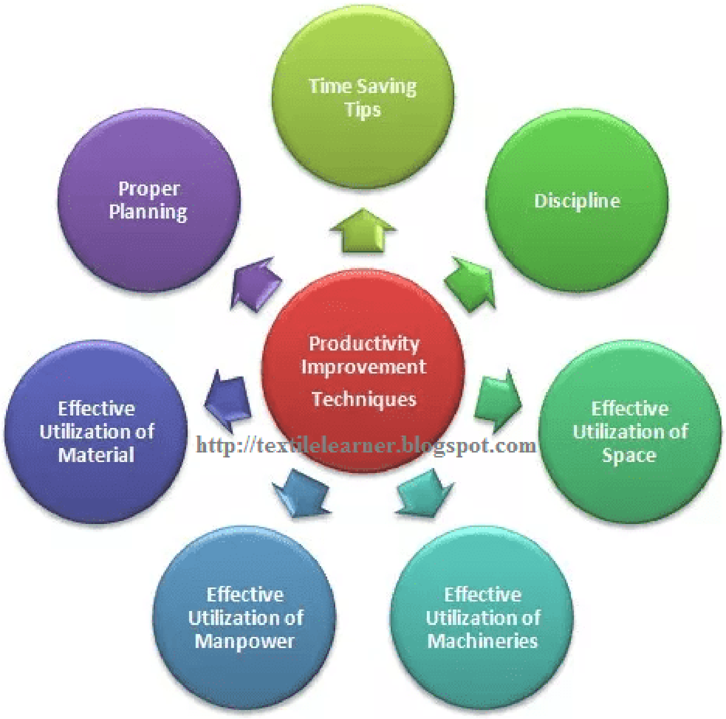

Figure 39. *Factors that affect efficiency in Footwear. Source: Textilelearner.blogspot*

Footwear manufacturing process can reduce the chemical impact seeking out materials that meet third party certification standards such as the **Global Organic Textile Standard (GOTS)**, or **Leather Working Group (LWG)** and collaborating with other companies in programmes such as **Zero Discharge of Hazardous Chemicals (ZDHC)**, which have created a roadmap for the footwear sector.

Figure 40. *GOTS; ZDHC*

The use of renewable energy is an important factor to reduce of fossil resources and Greenhouse gas emissions. Because footwear manufacturing is a low intensity energy consumer the use of photovoltaic solar panels is the common option for footwear companies. With this technology it is possible to obtain an average utilization of 30 percent of renewable energy and improve in this way environmental performance. This investment should be complemented with actions to improve energy efficiency like infrastructures changes, use of LEDs and gradual change for lower consuming production equipment.

Figure 41. *Photovoltaic solar panels*

A. Lean and Green

There are some new production methods, which could be revolutionary in terms of “sustainability”, aim at focusing on existing processes and to eliminate wastes. We can call this approach as a methodology Lean and Green. Sometimes a practical, solution-oriented approach and solid know-how are more important than working with the latest high-tech machinery.

“Just in time” means to organise production according to the so-called ”pull“-system and to delivery requirements of the customer. Production lots are subdivided into small units according to the ordered delivery quantities and according the existent orders.

The Toyota Production System maximises the ratio between added value time and idle time by eliminating overburden, inconsistency, and waste.

The principle is to add as much as possible value at the moment when the work pieces are held in hands and avoid defects and non-conforming footwear.

These lean tools are focused on fighting against all types of waste: energy, materials and, especially, labour.

LEAN AND GREEN

New production methods, which could be revolutionary in terms of “sustainability”, aim at focusing on existing processes and to eliminate wastes.

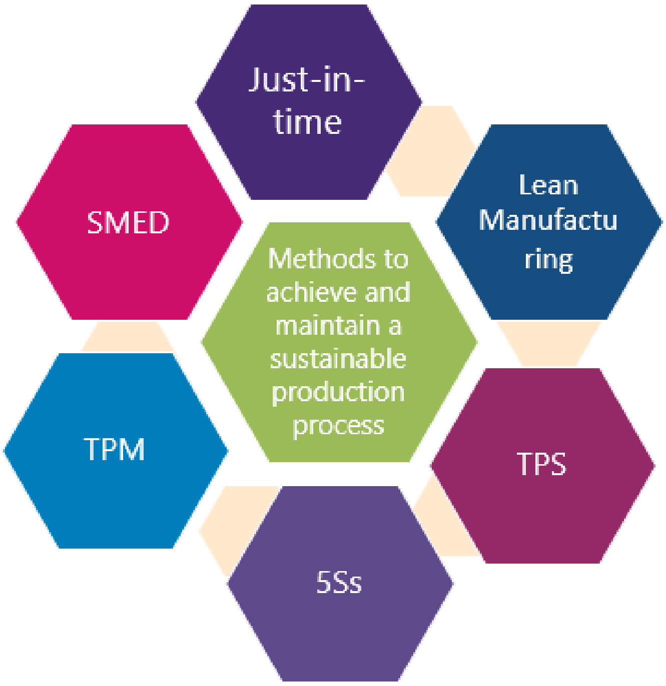

Figure 42. *Methods to achieve and maintain a sustainable production process*

B. Methods to improve environmental performance

A big portion of materials waste in footwear manufacturing is created during cutting process of leather and other materials. The small unusable materials parts are usually finishing on landfills directly with negative impact on the environment. Additionally, surplus waste material is created when stock of material is no longer required for the production. For example, leathers that were bought in excess due to miscalculation of needs or other causes, materials that the company had to bought by a minimal amount and other situations that cause stockage of unusable materials.

The efficiency of the process, include calculating correctly the needs, the precise stock management, the adequate buying, reception and cutting of the materials can avoid large quantities of waste and improve environmental performance of the footwear manufacturing process.

Figure 43. *Wastes from footwear industry.*

3.4. METHODS FOR IMPROVING ENVIRONMENTAL PERFORMANCE THROUGHOUT MANUFACTURING

Saving resources in an efficient way starts with the product concept / product development. The design process itself should be organised in a way to reduce the number of physical samples to a minimum. Modern CAD systems allowing for virtual prototyping are of great help to save resources and speed up time-to-market

Figure 44. *Footwear pattern making. Source: CTCP*

Modern CAD systems allowing for virtual prototyping are of great help to save resources and speed up time-to-market. Photorealistic 3D CAD images of shoe designs can considerably speed up the range creation process and save a lot of effort and resources invested in developing and prototyping shoe models which will finally not be part of the range. In this moment the design process can choose materials with less environmental impact and the integration of recycled materials.

The use of 3 D software to design new products permit to reduce the number of prototypes, reducing the use of materials, energy and labour and providing a faster process from the idea to initial selection of footwear and definition of a collection.

Pattern making

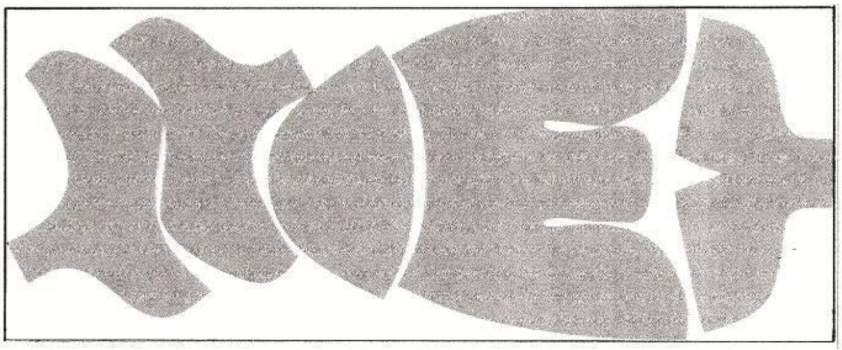

Figure 45. *Footwear nesting. Source: CTCP*

Most CAD systems can immediately calculate the first waste in the process of pattern making. If the first waste percentage is known, as well as the unit prices of leather, sole and lining materials, it's possible to estimate the global waste and act in this moment to make changes in pattern making to reduce the amount of waste projected. These changes can be done on the format of the pieces on the fitting between them. A well-trained team can improve the percentage of use of material and, with this reduce waste and save plenty of money if this process is systematically applied.

Cutting

The most important feature is that the positioning / nesting of the parts to be cut can be changed several times until the final cutting layout is found. Cutting itself does not start until the operator is satisfied with the cutting layout on the hide.This is not possible with traditional cutting and can permit the optimised utilisation of material to be cut.

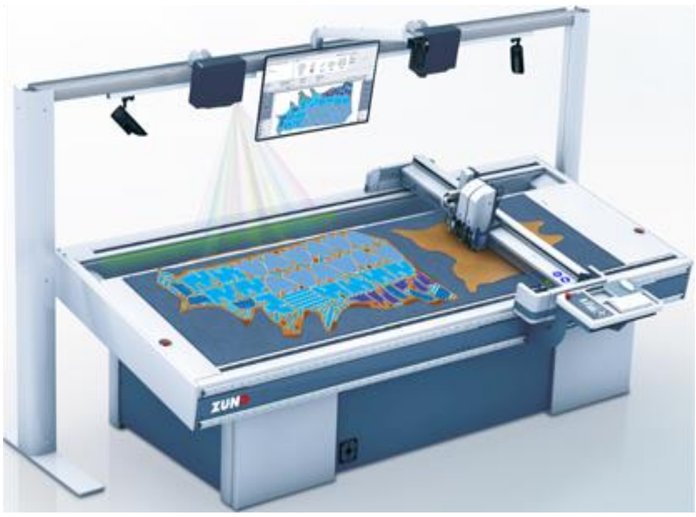

Figure 46. *Automatic footwear cutting system. Source: CTCP*

The process of cutting using automatic machines enables a more efficient use of resources without the need of Production of knives. The CAD system communicates the geometrical data of the parts to be cut to the CAM cutting table, the material is placed on the working area of the cutting table and the parts are projected onto the material. The parts are placed using desktop and mouse and the number of finished parts and the number of parts left to be cut is automatically displayed avoiding the cutting of excedents. Most CAM systems allow for simultaneous marking, numbering, and punching of the parts.

Pre-stitching

The most important feature is that the positioning / nesting of the parts to be cut can be changed several. In some pre-stitching operations, there are simple procedures that can be adopted to reduce their environmental impact in these cases in energy and labour resources. That is the case of operations like, splitting, skiving, and ironing. The best way to reduce their impact is to eliminate the need to execute these operations through the use of materials that don´t need these operations (all or some of them). If the footwear manufacturing process includes these operations, it is possible to reduce their environmental impact by:

Splitting:

- Adjust the machine according to the general setting advice
- Check the parameters at least once per week
- oil the lubrication felt
- check that both upper and bottom grinding stones wear out equally
- always change knife and grinding stones at the same time
- or, buy materials with no need of splitting

Skyving:

- Specify the type and width of skiving
- select the type of presser foot and feeding roller
- check the general adjustments, distances, constant pressing force
- confirm all adjustments in a trial using a piece of waste material
- or buy materials with no need of skiving

Ironing:

- The ironing parameters should be checked
- The temperature on the workpiece should be measured with a special sensor.
- The quality of the work result will only be satisfactory if the parameters are respected,
- Overheating, poor heating or low pressure will result in reworks or rejects
- Or buy materials with no need of ironing

Stitching

Stitching involves usually manual operations and operations done with stitching machines. An approach to reduce is to concentrate on operations which add value and which maintain the logical order of the work flow. In this case it is important to make a previous study of methods to analyse which is the best sequence of operations.

Another solution is to use automatic stitching machines. The use of these machines implies a previous study of the tools (stitching gabarits) and programming the stitching work. The better solution can be to minimise the use of seams, implementing, on the design a seamless process strategy.

Figure 47. *Automatic stitching machine. Source: CTCP*

Stitching - methods and times studies

Another important point to be considered is workplace organisation. This is important for all manufacturing processes but even more to stitching processes that in traditional Footwear manufacturing can represent 40 to 50 per cent of the job content.

The pieces of the work in progress must get to each workstation in a manner which facilitates picking them up and putting them down again. Tools or auxiliary materials should be placed in a way that they can easily be identified and handled.

Standard working tables often need to be enhanced by adding holders (for materials, tools or cleaning agents), extensions, surfaces, shelves, supports, waist disposal bags etc.

Adjustable chairs which ideally support each individual person have about the same importance in terms of performance and work result as clean workplaces.

Figure 48. *ctcp188-guia21-métodos-e-tempos.pdf*

Stitching – manual operations

Gluing is one of the most frequent manual operations in stitching Department. Many times, are used solvent based adhesives which imply the use of hazard chemical substances and besides the need of additional operations with low added value. Besides this, the use of based solvent adhesives causes glue dirt that has to be cleaned in the finishing Department.

But there are other options. To reduce the environmental impact of this process the company should reduce the use of gluing operations by improving methods, training operators to stitch directly without adhesive. This process must be complemented by the use of other adhesion processes, like the use of self-adhesive tapes or water-based adhesives only in operations where it is not possible direct stitching.

Figure 49. *Gluing footwear pieces. Source: CTCP*

Assembly operations

In assembly department, the upper is assembled onto the last. Depending on the type of construction of the shoe model, there is a sequence of different operations until the upper assembly is done. The selection of the type of construction is relevant because it determines the more or less use of resources (energy, labour, materials) by each pair of shoes manufactured.

Cemented is the most usual type of construction. But other constructions are now winning relevance like strobel and direct injection. Other constructions permit the production of footwear with minimal assembly operations as is the case of stitch and turn construction.

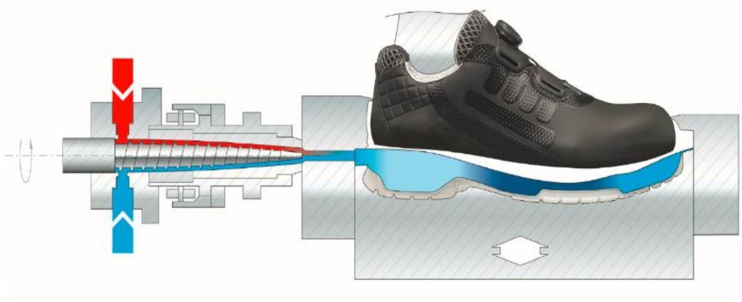

Figure 50. *Footwear injection process. Source: CTCP*

In assembly operations some recommendation and advises permit a more efficient process, improving environmental performance by a more efficient work with less non Quality and waste:

- create a list of parameters that need to be adjusted and keep record of how to adjust them for each model and fine tune them if needed
- provide precise work instructions for each model and/or material
- choice of the appropriate lasting machine or programme
- choice of glue application method
- set the time, pressure, temperature etc. according to the instructions
- keep the machine and the working place clean and carry out small preventive maintenance works
- Whenever possible use poke-yoke tools to Quality self control.

Figure 51. *Roughing. Source: CTCP*

Roughing and applying adhesive has a significant impact on the strength of the adhesive connection. New technologies include the use of CNC machines and robots to make these two operations. In terms of environmental performance CNC technologies can make a difference. The reproducibility of these operations avoids nonconformities on the execution of these operations which means less defects. A basic rule to have a better environmental performance is to avoid wastes and non-Quality products. In addition, the use of CNC machines in adhesion operations means the use of less adhesive with impact on resources used, organic volatile compounds emissions and less waste on the end of the manufacturing process.

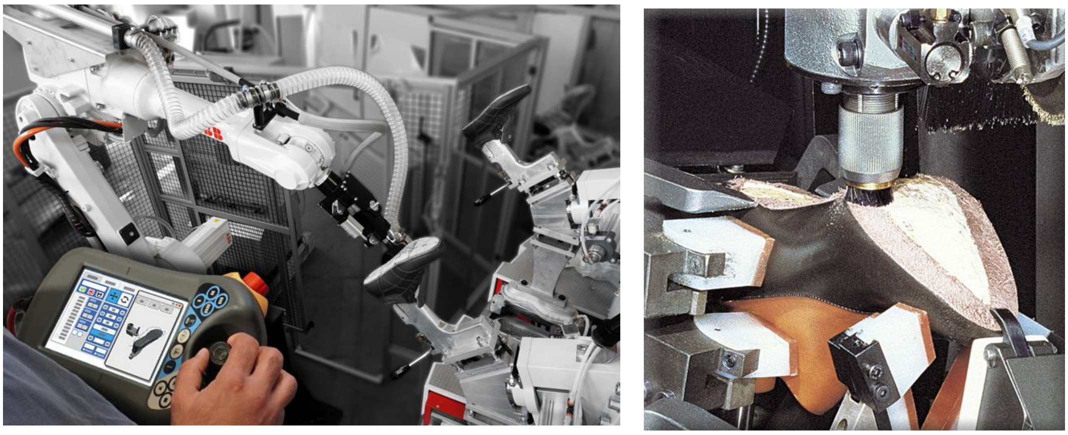

Figure 52. *Roughing, gluing and cementing. Source: CTCP*

5Ss

Throughout the manufacturing process is important to have the adequate organization of tools, materials and work in process. 5Ss is a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating waste, improving flow and reducing process unreasonableness. It stands for 5 steps to workplace organization, to ensure that the business is optimized for easy access of tools, equipment, material and information. It uses the following 5 simple steps:

Sort the workplace,

Set locations and limits of tools, material, storage, etc.

Shine – Fix things that are broken, paint equipment, clean and bring the place to a high standard.

Standardize the new ways of working for everyone to follow.

Sustain using leadership support and accountability to ensure the 5S system is being maintained by everyone.

***Figure 53**. 5Ss scheme. Source: CTCP*

LECTURE 4

HOW TO DESIGN AND IMPLEMENT PROJECTS IN RELATION TO THE LATEST DEVELOPMENTS ON NEW MANUFACTURING TECHNOLOGIES AND BUSINESS MODELS

4.1. INTRODUCTION

Understanding and implementing projects in the field of new manufacturing technologies and business models is a pillar for success in today's dynamic market landscape. Going deep into topics such as additive manufacturing, IoT integration, and emerging business models like servitization, one gains the essential knowledge needed to navigate the complexities of modern manufacturing. With a focus on project management fundamentals, innovation strategies, among others, this lecture will provide the tools to effectively plan, implement, and optimize projects.
Case studies will give insights into real-world applications and help to prepare to lead the charge in driving innovation and competitiveness in the manufacturing industry.

4.2. NEW MANUFACTURING TECHNOLOGIES

Additive manufacturing, robotics, and automation streamline production processes, improving efficiency and precision. The Internet of Things (IoT) integrates smart sensors and data analytics, enabling real-time monitoring and optimization. Advanced materials and composites enhance product durability and performance, while nanotechnology offers unprecedented precision and miniaturization capabilities. Together, these technologies are driving innovation, transforming supply chains, and shaping the future of manufacturing.

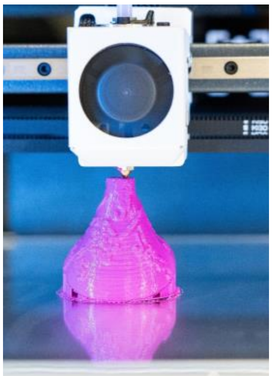

Figure 54.a. *3D Printing manufacturing*

Figure 54.b. *Robotics and automation*

Figure 54.c. *IoT in*

Figure 55*. Advanced materials & composite*

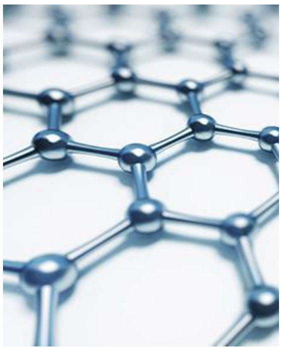

Figure 56*. Nanotechnology in manufacturing*

Additive manufacturing, or 3D printing, fabricates objects layer by layer from digital designs. It enables complex geometries, rapid prototyping, and on-demand production. Materials range from plastics to metals, fostering innovation across industries. With its flexibility and efficiency, 3D printing is reshaping manufacturing processes worldwide. As technology advances, its impact is poised to grow exponentially.

Robotics and automation streamline processes by using machines to perform tasks autonomously. They encompass various fields, from manufacturing to healthcare and beyond. Robotics improves efficiency, precision, and safety in repetitive or hazardous tasks. Automation reduces human intervention, leading to cost savings and increased productivity. Together, they revolutionize industries, driving innovation and shaping the future of work.

In manufacturing, the **Internet of Things (IoT)** connects machines, sensors, and devices to gather and exchange data in real-time. This interconnected network enables remote monitoring, predictive maintenance, and optimization of production processes. IoT enhances efficiency, reduces downtime, and improves decision-making through data-driven insights. By integrating IoT technologies, manufacturers can achieve greater automation, agility, and responsiveness in their operations. Ultimately, IoT transforms manufacturing into a more intelligent and interconnected ecosystem, driving innovation and competitiveness.

Advanced materials and composites are engineered substances with superior properties compared to traditional materials. They offer exceptional strength, durability, and lightweight characteristics. These materials find applications across various industries, including aerospace, automotive, and construction. By leveraging advanced manufacturing techniques, such as nanotechnology and carbon fiber reinforcement, they enable innovations in product design and performance. With ongoing research and development, advanced materials continue to push the boundaries of what is possible in material science, driving progress and sustainability.

Nanotechnology revolutionizes manufacturing by manipulating materials at the molecular or atomic scale. It enables precise control over properties like strength, conductivity, and flexibility.

Applications range from improving product performance to creating new materials with enhanced functionalities. Nanotechnology enhances efficiency, reduces waste, and facilitates the development of smaller, more powerful devices. By harnessing nanoscale phenomena, manufacturing processes are poised to achieve unprecedented levels of innovation and sustainability.

4.3. EMERGING BUSINESS MODELS

Emerging business models are reshaping industries by fostering innovation and connectivity. Companies are adopting circular economy principles to minimize waste and maximize resource efficiency, while B2C brands leverage online channels to forge direct connections with consumers. These models emphasize agility, customer-centricity, and sustainability, challenging traditional paradigms and driving value creation in the digital age. To thrive in this dynamic landscape, organizations must embrace experimentation, data-driven decision-making, and continuous adaptation to meet evolving market demands. By harnessing the power of emerging business models, businesses can unlock new opportunities for growth and differentiation in today's rapidly evolving business environment.

Understanding emerging business models	Industry 4.0 and smart factories
	Servitization: shifting from product to service-oriented business models
	Circular economy principles in manufacturing
	Mass customization and personalized manufacturing
	Platform-based business models

Understanding emerging business models:

Industry 4.0 and smart factories represent a transformative shift in manufacturing, encompassing a new business model that leverages advanced technologies to drive efficiency, flexibility, and innovation throughout the production process.

At the core of Industry 4.0 is the integration of cyber-physical systems, IoT, cloud computing, and artificial intelligence (AI) to create interconnected, intelligent factories. These smart factories enable real-time monitoring, predictive maintenance, and autonomous decision-making, leading to optimized production processes and enhanced productivity.

The new business model of Industry 4.0 emphasizes data-driven insights and automation, enabling manufacturers to respond quickly to changing market demands and customize products at scale. By leveraging interconnected systems and digital twins, companies can simulate and optimize production processes, reducing waste and improving quality.

Furthermore, Industry 4.0 facilitates greater collaboration across the value chain, as smart factories seamlessly connect with suppliers, distributors, and customers, enabling real-time information sharing and supply chain transparency. This enhanced connectivity fosters agile, demand-driven manufacturing, where production can be adjusted in response to customer preferences and market fluctuations.

Overall, Industry 4.0 and smart factories represent a paradigm shift in manufacturing business models, offering unprecedented opportunities for companies to drive innovation, improve operational efficiency, and deliver personalized products and services. Embracing this new model requires investments in technology infrastructure, workforce training, and organizational change management, but the potential benefits in terms of cost savings, competitive advantage, and customer satisfaction are substantial. As industries continue to evolve in the digital age, Industry 4.0 and smart factories will undoubtedly play a pivotal role in shaping the future of manufacturing.

Servitization represents a strategic shift in business models where companies transition from merely selling products to offering comprehensive service-based solutions. This transformation places an increased emphasis on delivering value-added services alongside traditional products, fostering long-term relationships with customers and driving sustainable revenue streams.

At the heart of servitization is the idea of selling outcomes or capabilities rather than just products. Instead of a one-time transaction, customers engage in ongoing partnerships where they pay for the results or benefits generated by the product over time. For example, instead of purchasing a piece of manufacturing equipment outright, a customer might opt for a service agreement where they pay based on machine uptime or output.

Servitization relies heavily on technology, particularly IoT sensors and data analytics, to monitor equipment performance, predict maintenance needs, and optimize service delivery. By leveraging real-time data and predictive analytics, companies can offer proactive maintenance services, reducing downtime and enhancing overall equipment effectiveness.

This new business model fosters closer collaboration between manufacturers and customers, as companies become more invested in the ongoing success and satisfaction of their clients. It also opens up new revenue streams and business opportunities, such as equipment leasing, pay-per-use models, and outcome-based pricing.

Moreover, servitization encourages a shift from a transactional mindset to one focused on long-term value creation and customer-centricity. Companies must prioritize customer needs and preferences, providing tailored solutions and continuously improving service offerings to meet evolving demands.

In conclusion, servitization represents a compelling new business model that enables companies to differentiate themselves in a competitive market, drive recurring revenue, and build stronger, more sustainable relationships with customers. By embracing servitization, organizations can unlock new opportunities for growth and innovation while delivering enhanced value and experiences to their clients.

Circular economy principles in manufacturing represent a novel business model that prioritizes sustainability and resource efficiency by minimizing waste and maximizing the reuse, recycling, and regeneration of materials and products throughout their lifecycle.
At its core, the circular economy model challenges the traditional linear "take-make-dispose" approach to manufacturing. Instead, it promotes a closed-loop system where materials are continuously cycled back into the production process, reducing reliance on finite resources and mitigating environmental impact.
One key aspect of circular economy principles in manufacturing is product design for durability, reparability, and recyclability. Companies are encouraged to design products with disassembly in mind, making it easier to recover and reuse components and materials at the end of their useful life.
Furthermore, manufacturers are exploring innovative strategies such as remanufacturing, where used products are refurbished to like-new condition, extending their lifespan and reducing the need for new production. Additionally, recycling and upcycling initiatives are gaining traction, with companies finding creative ways to repurpose waste materials into new products or inputs for other industries.
The circular economy model also emphasizes the importance of collaboration and transparency across the value chain. Manufacturers are working closely with suppliers, customers, and other stakeholders to identify opportunities for waste reduction, resource optimization, and material recovery.
From a business perspective, embracing circular economy principles can lead to several benefits, including cost savings through reduced material usage and waste disposal costs, enhanced brand reputation as a sustainable and responsible company, and improved resilience to supply chain disruptions by diversifying material sources and reducing dependence on virgin resources.
Overall, circular economy principles in manufacturing offer a promising new business model that aligns economic growth with environmental sustainability. By adopting a closed-loop approach to production, companies can not only reduce their environmental footprint but also drive innovation, create new revenue streams, and build a more resilient and regenerative economy for the future.

Mass customization and personalized manufacturing represent a transformative business model that combines the efficiency of mass production with the flexibility and personalization of bespoke craftsmanship. This approach allows companies to offer a wide range of customizable options to meet individual customer preferences and requirements while still benefiting from economies of scale.
At the core of mass customization is the use of advanced technologies such as digital design tools, automation, and data analytics to streamline the production process and enable efficient customization. By leveraging these technologies, companies can create highly adaptable manufacturing systems capable of producing a diverse array of products tailored to each customer's specifications.

One of the key advantages of mass customization is its ability to meet the growing demand for personalized products and experiences in today's consumer-driven market. By offering customizable options such as color, size, features, and branding, companies can engage customers on a deeper level, fostering loyalty and driving repeat business.
Moreover, mass customization enables companies to respond quickly to changing market trends and customer preferences, as production can be adjusted in real-time based on demand signals and feedback. This agility allows companies to stay ahead of competitors and capitalize on emerging opportunities in the market.
From a business perspective, mass customization offers several benefits, including higher profit margins due to premium pricing for customized products, reduced inventory costs through on-demand manufacturing, and increased customer satisfaction and loyalty.
However, implementing mass customization requires significant investment in technology infrastructure, workforce training, and supply chain optimization. Companies must also carefully balance the trade-offs between customization and standardization to ensure efficiency and scalability.
Overall, mass customization and personalized manufacturing represent a compelling new business model that enables companies to differentiate themselves in a competitive market, meet the evolving needs of customers, and drive innovation and growth. By embracing customization as a core strategy, companies can unlock new opportunities for value creation and long-term success in the digital age.

Platform-based business models have emerged as a disruptive force in various industries, revolutionizing traditional approaches to value creation and exchange. At their core, these models leverage digital platforms to facilitate interactions and transactions between different user groups, unlocking new opportunities for innovation, collaboration, and value capture.
Central to platform-based business models is the creation of a digital ecosystem that connects producers, consumers, and other stakeholders in a networked marketplace. These platforms serve as intermediaries, providing infrastructure, tools, and services that enable participants to interact, transact, and create value in novel ways.
One of the defining features of platform-based business models is their scalability and network effects. As more users join the platform, the value of the network increases, leading to a virtuous cycle of growth and engagement. This scalability allows platforms to rapidly expand their reach and impact, disrupting traditional business models and incumbents.
Moreover, platform-based business models often leverage data-driven insights and algorithms to personalize and optimize the user experience. By capturing and analyzing vast amounts of data generated by user interactions, platforms can tailor recommendations, customize offerings, and enhance engagement, leading to higher customer satisfaction and retention.
Examples of successful platform-based business models abound across industries, from ride-sharing platforms like Uber and Lyft to e-commerce giants like Amazon and Alibaba. These platforms have

transformed the way people access goods and services, creating new opportunities for entrepreneurship, employment, and economic growth.

However, platform-based business models also present unique challenges and considerations, including regulatory scrutiny, data privacy concerns, and competition issues. Companies must navigate these challenges while maintaining trust, transparency, and fairness within their ecosystems to ensure long-term sustainability and success.

Overall, platform-based business models represent a powerful and disruptive force in today's digital economy, reshaping industries, redefining value chains, and democratizing access to resources and opportunities. As technology continues to evolve and connectivity deepens, the potential for innovation and growth within platform ecosystems is virtually limitless, making them a compelling avenue for businesses seeking to thrive in the digital age.

4.4. PROJECT MANAGEMENT FUNDAMENTALS

Project management fundamentals are essential for successful project execution. They encompass planning, scheduling, and resource allocation to ensure timely delivery. Risk management identifies and mitigates potential obstacles, ensuring project progress remains on track. Effective communication and stakeholder management foster collaboration and alignment throughout the project lifecycle. By adhering to these principles, project managers can achieve their objectives efficiently and effectively.

Project management fundamentals	Project planning and scheduling
	Resource allocation and management
	Risk management in manufacturing projects
	Budgeting and cost control
	Stakeholder management

Project planning and scheduling are essential aspects of effective project management, ensuring that tasks are organized, resources are allocated efficiently, and timelines are met. This involves breaking down the project into manageable tasks, estimating their duration and resource requirements, and creating a timeline or schedule that outlines the sequence of activities and milestones. By meticulously planning and scheduling, project managers can identify dependencies, mitigate risks, and allocate resources effectively, ultimately maximizing productivity and ensuring the successful completion of the project within budget and timeframe.

Resource allocation and management are critical components of successful project execution, involving the strategic distribution and utilization of resources such as personnel, equipment, and funds. This process requires careful planning to ensure that resources are allocated efficiently to meet project objectives while minimizing waste and maximizing productivity. Effective resource management involves identifying resource requirements, assessing availability, prioritizing tasks, and monitoring resource usage throughout the project lifecycle. By optimizing resource allocation, project managers can mitigate bottlenecks, reduce costs, and ensure that projects are completed on time and within budget, ultimately driving success and achieving organizational goals.

In manufacturing projects, **risk management** is essential to ensure smooth operations and successful outcomes. It involves identifying potential risks, assessing their likelihood and impact, and developing strategies to mitigate or address them. Common risks in manufacturing projects include supply chain disruptions, quality control issues, equipment failures, and market fluctuations. By proactively managing risks, manufacturers can minimize disruptions, protect assets, and maintain project timelines and budgets. This proactive approach fosters resilience and agility, enabling manufacturers to navigate uncertainties and optimize performance in dynamic environments.

Budgeting and cost control are essential components of effective project management, particularly in manufacturing projects where resources are often limited and expenses must be carefully managed. Budgeting involves estimating the costs associated with various project activities, including materials, labor, equipment, and overhead expenses. Cost control encompasses monitoring actual expenditures, identifying variances from the budget, and implementing corrective measures to ensure that spending remains within approved limits. By establishing a realistic budget and diligently tracking expenses, project managers can optimize resource allocation, minimize waste, and maintain financial stability throughout the project lifecycle. This disciplined approach to budgeting and cost control is critical for achieving project objectives on time and within budget constraints.

Stakeholder management is vital for the success of any project, particularly in manufacturing where multiple parties are involved. It involves identifying and understanding the needs, interests, and expectations of stakeholders such as customers, suppliers, employees, and regulatory bodies. Effective stakeholder management entails engaging stakeholders early and often, fostering open communication, addressing concerns proactively, and ensuring alignment with project objectives. By prioritizing stakeholder relationships and managing expectations, project managers can build trust, mitigate conflicts, and secure support, ultimately enhancing project outcomes and driving long-term success.

4.5. TECHNOLOGY ADOPTION AND IMPLEMENTATION

Technology adoption and implementation are crucial for staying competitive in today's fast-paced environment. Assessing technology readiness helps in selecting and integrating appropriate solutions into existing systems. Pilot testing ensures smooth deployment, while scaling up maximizes the benefits across the organization. Training and workforce development are essential for smooth adoption and utilization of new technologies. Continuous evaluation ensures that technology remains aligned with business goals and evolves to meet changing needs.

Technology adoption and implementation	Technology readiness assessment
	Pilot testing and scaling up new technologies
	Integration of new technologies with existing systems
	Training and workforce development for technology adoption
	Performance measurement and evaluation

Technology readiness assessment is a systematic process used to evaluate the maturity and feasibility of adopting new technologies within an organization. It involves assessing various factors such as technical complexity, readiness level, risks, and potential benefits associated with implementing the technology. TRA helps decision-makers make informed choices about whether to invest in and deploy specific technologies by providing insights into their compatibility with existing systems, resource requirements, and potential impact on business operations. By conducting a thorough technology readiness assessment, organizations can mitigate risks, optimize resource allocation, and increase the likelihood of successful technology adoption and implementation.

Pilot testing involves the initial deployment of new technologies on a smaller scale within a controlled environment or subset of users. This phase allows organizations to assess the performance, functionality, and usability of the technology in real-world conditions while minimizing risks and disruptions to the entire operation. Feedback gathered during pilot testing is crucial for identifying potential issues, refining processes, and making necessary adjustments before full-scale implementation.

Scaling up new technologies involves expanding their deployment across the organization or to a larger user base after successful pilot testing. This phase requires careful planning, resource allocation, and coordination to ensure a smooth transition from pilot to full-scale deployment. It may involve upgrading infrastructure, training employees, and adjusting workflows to accommodate the increased use of the technology. Additionally, scaling up often involves addressing scalability challenges, optimizing performance, and addressing any remaining issues identified during the pilot phase.

Overall, pilot testing and scaling up are critical stages in the technology adoption process, allowing organizations to validate new technologies, mitigate risks, and maximize their impact on business operations. By systematically transitioning from pilot to full-scale deployment, organizations can realize the full potential of new technologies while minimizing disruptions and ensuring a successful implementation.

Integration of new technologies with existing systems is a crucial aspect of successful technology adoption within organizations. It involves seamlessly incorporating new tools, platforms, or solutions into the current infrastructure to enhance functionality, efficiency, and productivity.
This process requires careful planning, assessment of compatibility, and consideration of existing workflows and processes. Compatibility issues may arise due to differences in data formats, protocols, or architectures, necessitating the development of custom interfaces or middleware to facilitate communication between systems.
Effective integration also involves ensuring data integrity, security, and privacy across all integrated systems. This may require implementing robust authentication mechanisms, encryption protocols, and access controls to safeguard sensitive information and mitigate cybersecurity risks.
Moreover, integration efforts should prioritize interoperability, allowing different systems to communicate and exchange data seamlessly. This enables information flow across departments, facilitates collaboration, and enhances decision-making capabilities.
Continuous monitoring and testing are essential to ensure that the integrated systems operate smoothly and deliver the expected benefits. Regular maintenance, updates, and troubleshooting help address any issues that may arise over time and ensure optimal performance.
Ultimately, successful integration of new technologies with existing systems enables organizations to leverage their investments, streamline operations, and stay competitive in an ever-evolving business landscape. By aligning technology initiatives with business objectives and effectively integrating new solutions, organizations can maximize their return on investment and drive sustainable growth.

Training and workforce development play a crucial role in facilitating the successful adoption of new technologies within organizations. It involves equipping employees with the necessary knowledge, skills, and competencies to effectively use and leverage the capabilities of the new technologies.
Training programs should be tailored to the specific needs of the organization and the requirements of the technology being adopted. This may include hands-on workshops, online courses, instructor-led training sessions, or a combination of various learning modalities.
Effective training programs not only focus on teaching technical skills but also emphasize the broader context of how the technology fits into the organization's workflows, processes, and strategic objectives. This helps employees understand the value proposition of the technology and how it can contribute to their individual roles and responsibilities.
Furthermore, ongoing support and continuous learning opportunities are essential to ensure that employees remain proficient in using the technology and stay abreast of updates, new features, and best practices. This may involve establishing dedicated support channels, providing access to user manuals and knowledge bases, or offering refresher courses and advanced training sessions.
Investing in training and workforce development not only empowers employees to embrace new technologies but also fosters a culture of innovation, collaboration, and continuous improvement within the organization. It helps build confidence, resilience, and adaptability among employees,

enabling them to navigate technological changes effectively and contribute to the organization's success in the long run.

Performance measurement and evaluation are critical components of assessing the effectiveness and impact of technology adoption initiatives within organizations. It involves systematically collecting, analyzing, and interpreting data to gauge the extent to which technology implementation aligns with predefined goals, objectives, and key performance indicators (KPIs).

Performance measurement begins by defining clear and measurable objectives that reflect the desired outcomes of technology adoption efforts. These objectives may include improving operational efficiency, enhancing customer satisfaction, reducing costs, increasing revenue, or achieving other strategic objectives.

Once objectives are established, relevant performance metrics and KPIs are identified to track progress and evaluate success. These metrics may vary depending on the nature of the technology being adopted and the specific goals of the organization but often include indicators such as productivity, quality, user adoption rates, downtime, customer satisfaction scores, and return on investment (ROI).

Regular monitoring and analysis of performance data enable organizations to identify trends, patterns, and areas for improvement. It helps stakeholders make informed decisions, allocate resources effectively, and adjust strategies as needed to optimize technology utilization and maximize outcomes.

In addition to quantitative metrics, qualitative feedback from stakeholders, end-users, and other relevant parties is also valuable for evaluating the impact of technology adoption initiatives. Surveys, interviews, focus groups, and user feedback sessions provide insights into user experiences, satisfaction levels, and areas for enhancement.

Ultimately, performance measurement and evaluation serve as a continuous feedback loop, enabling organizations to assess progress, identify successes and challenges, and make data-driven decisions to drive continuous improvement and innovation in technology adoption efforts. By establishing robust performance measurement mechanisms, organizations can ensure that technology investments deliver tangible benefits, support strategic objectives, and drive sustainable growth.

4.6. DESIGN THINKING AND INNOVATION

Design thinking is a human-centred approach to problem-solving and innovation that emphasizes empathy, creativity, and iterative experimentation. It involves a structured process of understanding user needs, generating ideas, prototyping solutions, and testing them in real-world settings. Design thinking encourages multidisciplinary collaboration and a willingness to embrace ambiguity and failure as integral parts of the innovation journey.

The relationship between design thinking and innovation is symbiotic and mutually reinforcing. Design thinking provides a framework for fostering innovation by challenging assumptions, exploring diverse perspectives, and uncovering latent needs and opportunities. By prioritizing empathy and understanding, design thinking helps organizations develop solutions that truly resonate with users and address their underlying needs and desires, leading to more meaningful and impactful innovations.
Moreover, design thinking promotes a culture of experimentation and iteration, where failure is seen as a valuable learning experience rather than a setback. This mindset encourages risk-taking and creativity, fostering an environment conducive to breakthrough innovation and continuous improvement.
In essence, design thinking serves as a catalyst for innovation by providing a structured yet flexible approach to problem-solving that places human needs and experiences at the forefront. By embracing the principles of design thinking, organizations can unlock new possibilities, drive user-centric innovation, and create products, services, and experiences that make a meaningful difference in people's lives.

Design thinking typically involves several iterative steps, which may vary slightly depending on the source, but generally include the following:

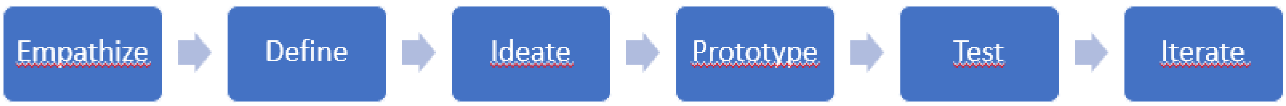

***Figure 57**. – Design Thinking STEPS. Source: CTCP*

Empathize: Understand the needs and perspectives of the users or stakeholders for whom you are designing. This involves engaging with them directly through interviews, observations, or other research methods to gain deep insights into their experiences, challenges, and aspirations.

Define: Synthesize the information gathered during the empathize phase to define the core problems or opportunities you aim to address. This step involves reframing the insights gained into actionable problem statements or design challenges that will guide the rest of the process.

Ideate: Generate a wide range of potential solutions to the defined problems through brainstorming and creative thinking techniques. Encourage a diverse range of perspectives and ideas, prioritizing quantity over quality at this stage and deferring judgment to foster creativity.

Prototype: Build rough, low-fidelity representations of your ideas to quickly and cheaply test and refine them. Prototypes can take various forms, such as sketches, wireframes, mockups, or even physical models, depending on the nature of the problem and the potential solutions.

Test: Gather feedback from users or stakeholders by testing your prototypes in real-world scenarios. This step involves observing how users interact with the prototypes, soliciting their feedback, and iterating on the designs based on their input.

Iterate: Repeat the design process iteratively, refining and improving your solutions based on the insights gained from testing and feedback. Each iteration should bring you closer to a viable, user-centered solution that effectively addresses the identified problems or opportunities.

These steps are not necessarily linear and may overlap or be revisited multiple times throughout the design process. The goal is to foster a flexible, iterative approach that prioritizes empathy, creativity, and collaboration to drive innovative solutions that meet the needs of users and stakeholders.

4.7. INTELLECTUAL PROPERTY AND LEGAL CONSIDERATIONS

Intellectual Property (IP) and legal considerations are essential in safeguarding innovations and creations. They encompass patents, trademarks, copyrights, and trade secrets, protecting intellectual assets from infringement and unauthorized use. Understanding IP laws and regulations is crucial for navigating licensing agreements, contractual obligations, and litigation risks. Compliance with industry standards and regulations ensures legal protection and fosters trust with stakeholders. Ethical considerations regarding IP rights promote fair competition and responsible innovation in the marketplace.

To take into consideration	IP protection strategies for new technologies
	Licensing and technology transfer agreements
	Compliance with industry standards and regulations
	Contract negotiation and dispute resolution
	Ethics and social responsibility in technology projects

IP protection strategies for new technologies involve obtaining patents, trademarks, copyrights, or trade secrets to safeguard intellectual property. Patents provide exclusive rights to inventors, preventing others from making, using, or selling the invention for a limited time. Trademarks protect brand names, logos, and symbols, ensuring recognition and preventing unauthorized use. Copyrights safeguard original works of authorship, such as software code or creative content, from reproduction or distribution without permission. Trade secrets involve keeping proprietary information confidential to maintain a competitive advantage. Implementing a comprehensive IP protection strategy is crucial for safeguarding innovations and maintaining a competitive edge in the market.

Licensing and technology transfer agreements enable the legal transfer of intellectual property rights from one party to another. These agreements outline the terms for using, modifying, or commercializing the technology or innovation. They facilitate collaboration between innovators and businesses, allowing for the monetization of intellectual property assets. Through licensing, companies can access new technologies, expand their product offerings, or enter new markets without significant upfront investment in research and development. Effective negotiation and clear contractual terms are essential to ensure mutual benefit and mitigate potential risks for all parties involved.

Compliance with industry standards and regulations is essential for ensuring product quality, safety, and legality. These standards dictate specific requirements and guidelines that companies must follow to meet industry expectations and legal obligations. Adhering to standards fosters consumer trust, enhances market competitiveness, and mitigates risks associated with non-compliance, such as fines or legal liabilities. Regular monitoring and updates to standards help companies stay current with evolving regulatory landscapes and maintain a reputation for integrity and reliability within their respective industries.

Contract negotiation involves parties discussing and agreeing upon terms, conditions, and obligations to establish a legally binding agreement. Effective negotiation requires clear communication, compromise, and a thorough understanding of each party's needs and objectives. In the event of disputes, mediation, arbitration, or litigation may be employed to resolve conflicts and uphold contractual obligations. Prompt and fair dispute resolution is crucial for maintaining business relationships, minimizing financial losses, and preserving reputations. Successful negotiation and dispute resolution contribute to the stability and integrity of commercial transactions.

Ethics and social responsibility in technology projects entail considering the impact of innovations on individuals, communities, and the environment. Upholding ethical principles ensures that technology development and implementation prioritize fairness, transparency, and respect for human rights. Tech projects should address societal concerns, such as privacy, diversity, and sustainability, to foster trust and inclusivity. Embracing social responsibility involves engaging stakeholders, mitigating potential harms, and maximizing positive contributions to society. By integrating ethical considerations, technology projects can drive meaningful progress while minimizing adverse effects on people and the planet.

4.8. CASE STUDIES

Case studies demonstrate how companies can leverage new manufacturing technologies and business models to drive innovation, improve efficiency, and create value for customers and stakeholders. By embracing these approaches, organizations can stay ahead of the curve in an increasingly competitive and rapidly evolving business environment.

- Success stories of companies implementing new technologies and business models
- Real-world examples of innovative manufacturing projects

Tesla Inc.:

Tesla has revolutionized the automotive industry by integrating advanced manufacturing technologies, such as **robotics and automation**, with a unique business model focused on electric vehicles (EVs) and sustainable energy solutions. Their Gigafactories employ cutting-edge manufacturing processes to produce batteries, electric drivetrains, and vehicles at scale. Tesla's direct-to-consumer sales model and emphasis on over-the-air software updates have disrupted traditional dealership models and enabled rapid innovation and iteration.

Adidas Speedfactory:

Adidas introduced its Speedfactory concept, leveraging **additive manufacturing** (3D printing) and robotics to revolutionize footwear production. The Speedfactory combines advanced manufacturing technologies with localized production, allowing for greater customization and shorter lead times. By implementing this innovative business model, Adidas can respond quickly to consumer trends and preferences, reduce transportation costs, and minimize environmental impact.

General Electric (GE) Aviation:

GE Aviation has embraced **additive manufacturing** technologies, such as 3D printing, to transform aircraft engine production. By using advanced materials and composites, GE Aviation has reduced the weight and improved the performance of engine components while simplifying the manufacturing process. This innovative approach has enabled GE Aviation to deliver more fuel-efficient engines, reduce maintenance costs, and gain a competitive edge in

4.9. CONCLUSIONS

The journey of designing and implementing projects on new manufacturing technologies and business models is both challenging and rewarding. By embracing innovation, leveraging emerging technologies, and adopting agile methodologies, organizations can stay ahead of the curve in a rapidly evolving landscape. Through strategic planning, effective project management, and a commitment to sustainability, businesses can unlock new opportunities for growth and competitiveness. As we continue to explore the frontiers of manufacturing, let us remain vigilant in our pursuit of excellence, always striving to push boundaries, drive change, and create a brighter future for industries worldwide.

LECTURE 5
CIRCULAR SUPPLY CHAIN MANAGEMENT

5.1. INTRODUCTION

Supply Chain Management (SCM) is the centralized management of the flow of goods and services to and from a company and includes all the processes involved in transforming raw materials and components into final products. With focus in sustainability, Circular Economy principles are integrated in SCM, developing new concerns and processes to implement Circular Supply Chain Management (CSCM), a more effective process with economic, environmental and social benefits for all the stakeholders.

5.2. WHAT IS SUPPLY CHAIN MANAGEMENT

First of all, what is Supply Chain Management (SCM)?
In today's global economy, supply chains are often vast and complex, spanning multiple countries and involving hundreds of different businesses. To effectively manage a supply chain, businesses need to have visibility into every step of the process, from raw materials procurement all the way through to end-consumer sales. Effective SCM can help streamline a company's activities to eliminate waste, maximize customer value, and gain a competitive advantage in the marketplace.

Figure 58. *Production line-sneakers. Source: http://institutviladomat.cat/portfoli/15bertafernandez/2018/04/27/sweatshops-the-mad-factorys/*

There are some new production methods, which could be revolutionary in terms of "sustainability", aim at Although it may seem like a simple process, SCM is actually a very complex and dynamic field that involves many different elements. Here are five of the most important:

Figure 59. *What's Supply Chain Management.*
Source: https://www.apsfulfillment.com/e-commerce-fulfillment/supply-chain-management/

Planning: To ensure that products are delivered on time and in the correct quantities, SCM practitioners must carefully plan every step of the process. This includes forecasting demand, estimating lead times, and creating production schedules.

Sourcing: Another key element of SCM is sourcing. This involves working with suppliers to procure the raw materials and components needed to produce finished goods. In some cases, sourcing can also involve reverse logistics or the process of returning defective or surplus items to suppliers.

Manufacturing: Once the necessary materials have been sourced, it's time to start manufacturing products. This stage of SCM requires close coordination between different departments, such as engineering, quality control, and assembly.

Delivering: The next step is to get products from the manufacturing facility to customers. This can be done through various distribution channels, such as direct shipment, retailers, or wholesalers.

Returning: Finally, SCM practitioners must also be prepared to handle returns and other post-purchase activities. This can involve anything from providing customer support to processing refunds and exchanging defective items.

2.1. What is Circular Supply Chain Management

Linear economic model of take-make-consume-dispose, is based on the idea that resources are abundant, easy to obtain and cheap to dispose of. Alternative Circular Model in which the planet´s environmental boundaries are respected by conserving resources and maximizing the use of all resources. Circular economy model envolves increasing the use of renewable or recycled resources while reducing the consumption of raw materials and energy, and, at the same time, decreasing emissions and materials losses.

Figure 60. *The circular economy model Source: https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefit*

One possible definition says that sustainable supply chain management is the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements.

A circular supply chain doesn't end with the end user. After the item is used, it is brought back into the supply chain (a process known as ***Reverse logistics***) to be recycled or refurbished, repackaged, redistributed and resold.

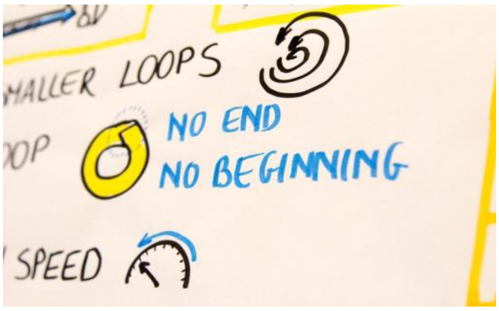

Figure 61. *The circular economy model*

Source: https://www.enviroessentials.com.au/blog/2023/08/environmental-kpis-guide/

The circular economy is a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources.

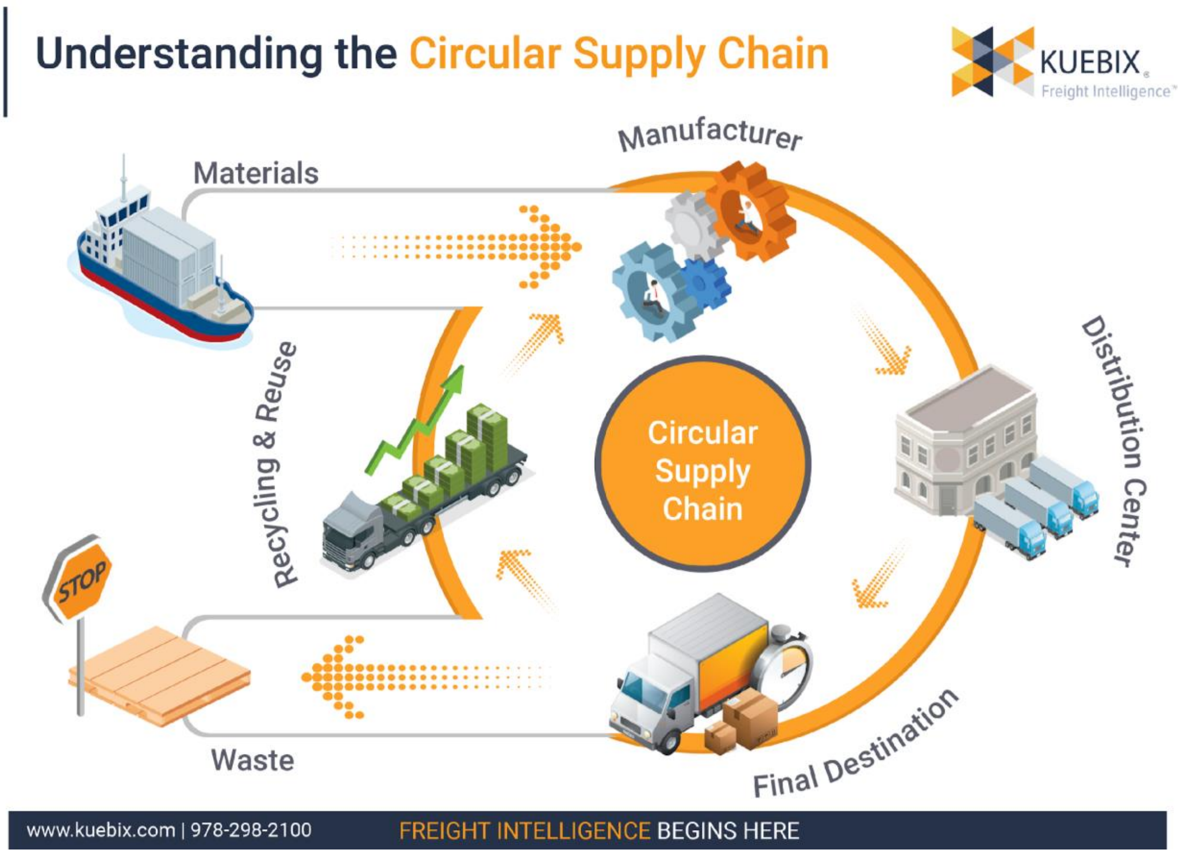

Figure 62. *Understanding the Circular Supply Chain*

Source: https://www.kuebix.com/circular-supply-chain-missing-link/

What is a circular supply chain management? A Circular supply chain integrates the principles of circular economy on Supply chain management. A circular supply chain is where used products or their parts are returned or processed so they can be repaired, resold, refurbished or recycled – which reduces waste from the supply chain and is more sustainable.

5.3. RELEVANT FACTORS TO CONSIDER ON CIRCULAR SUPPLY CHAIN MANAGEMENT

Throughout the supply chain all the parts making part of the supply chain must be committed to Environmental, Social and Governance principles, implementing actions to improve their ESC score and reduce the risks associated to noncompliance to all supply chain.

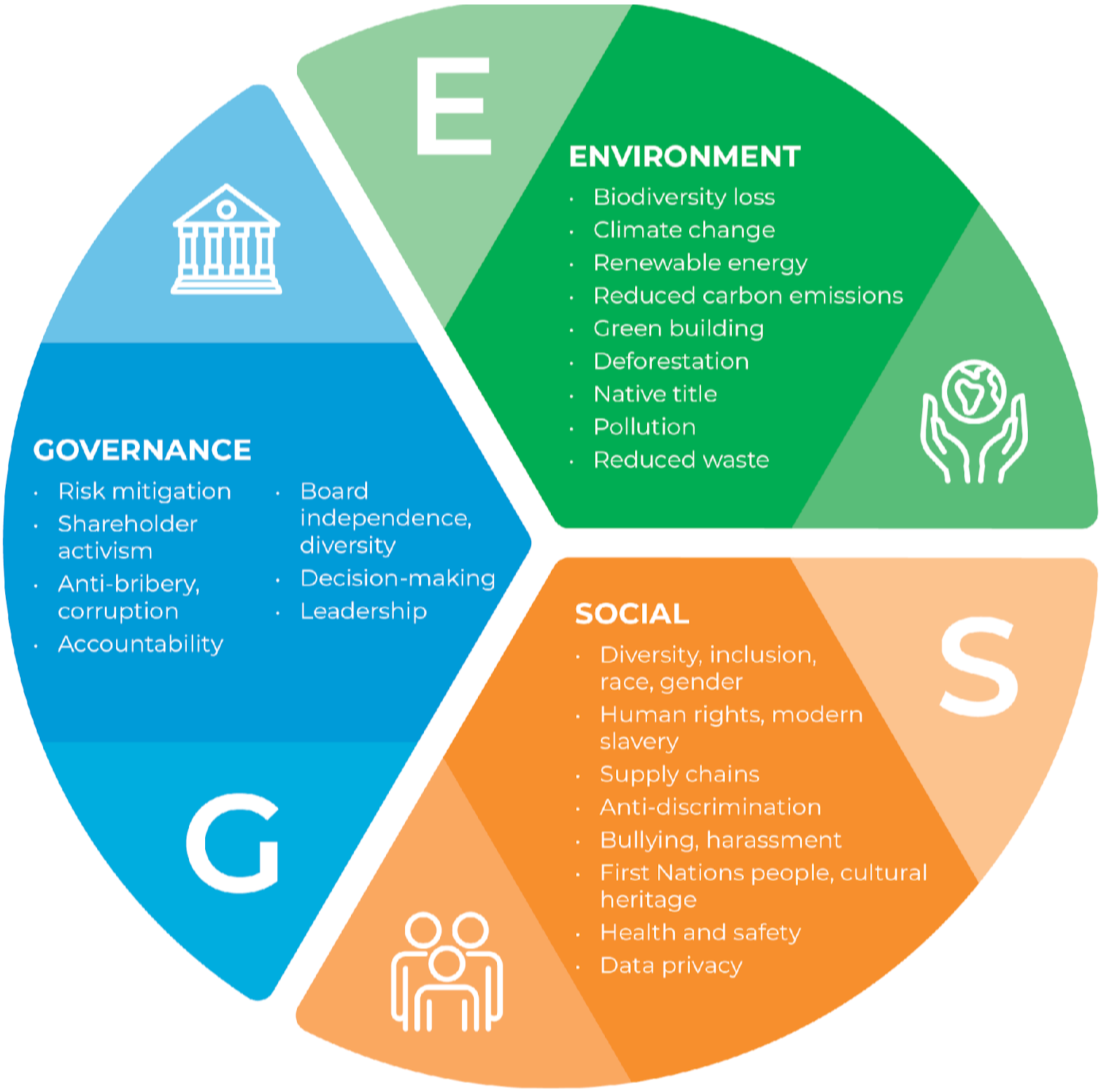

Figure 63. *Circular Supply Chain Management. Source: https://www.holdingredlich.com/environmental-social-and-governance-esg-explained-five-important-considerations-for-companies-and-their-lawyers*

Planning of the Circular Supply Chain Management must consider the necessity of reducing carbon footprint of each organization and product that is being made from cradle to cradle (loop process) or from cradle to grave, if it is not possible to assure the return of the product to be reintegrated on the manufacturing process. Strategies to improve the use recyclable materials and incorporate recycled materials must be implemented.

Figure 64. *Relevant factors on Circular Supply Chain Management.*
Source: https://www.tarkett-group.com/en/climate-circular-economy/carbon-footprint/

Circular Supply Chain Management implies planning the flow of product in the end of his life. Actually, most of the products don´t have a defined solution to return to the process to be reincorporated as a recycled material. In some countries the use of locals to depose clothes and shoes promote their reuse but don´t avoid waste and the necessity to integrate virgin materials in sourcing and manufacturing. This possibility cannot be considered a circular supply chain management process.

Figure 65. *Source: https://www.shutterstock.com/image-photo/melbourne-vicaustraliajuly-29nd-2019-reusable-clothes-1467145199/*

When we look to Circular Supply Chain Management, we understand that the steps defined on our strategy of Supply Chain Management must be completed with additional requirements on Planning, Sourcing, Manufacturing, Delivering, and Returning and that key words like Transparency, Traceability, Compliance and ESG parameters must be included.

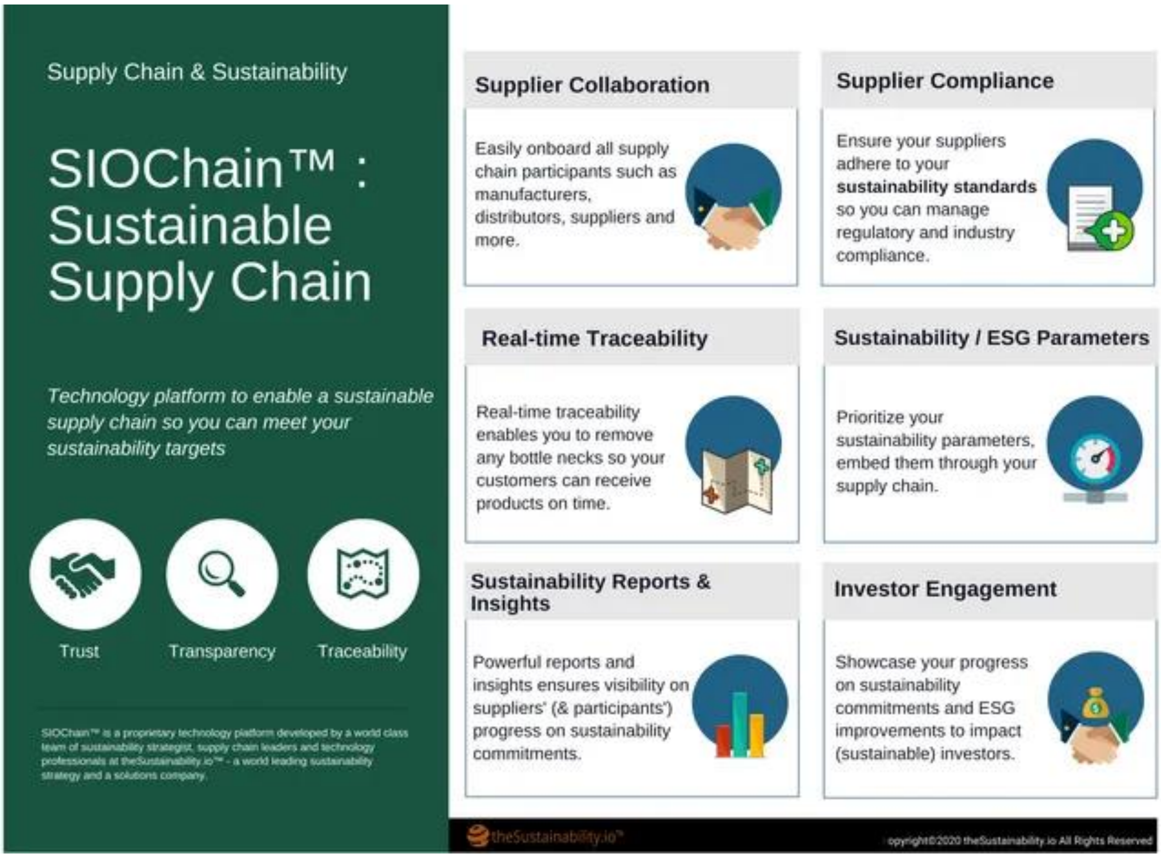

Figure 66. *Source: https://www.thesustainability.io/supply-chain-sustainability*

Closing the loop must be part of a Circular Supply Chain Management process. When planning the process must be assured the collection of the product in shops or by online processes easy to be used and, when possible, with benefits for consumer, brand and manufacturer.

The integration of recycled materials reduces waste – end of life of the shoes – and reduces the necessity of sourcing new materials. Planning must consider the involvement of consumers, stores, the existence of a circuit to collect and transport shoes to recycling infrastructures and after to the manufacturing company.

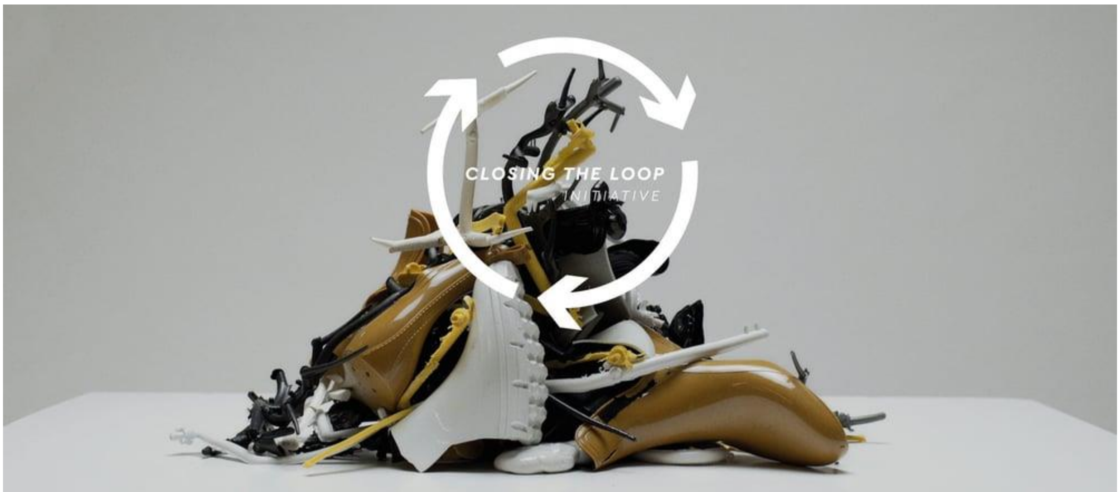

Figure 67. *Source: https://pt.fashionnetwork.com/news/Lemon-jelly-aposta-na-economia-circular,1250107.html*

5.4. EXAMPLES OF CIRCULAR SUPPLY CHAIN MANAGEMENT PROCESSES

Instead of throwing it away, leave it with us. We'll clean and donate or recycle your used athletic gear to make sure it lives on, even when you're done wearing it. This is what the brand Nike says to its clients. The Nike`s program involves selected participating Nike stores in the United States that are piloting this new Recycling and Donation program where the client can drop-off both Nike footwear and apparel. Nike refers that is constantly adding new stores to list to help make sustainability more accessible.

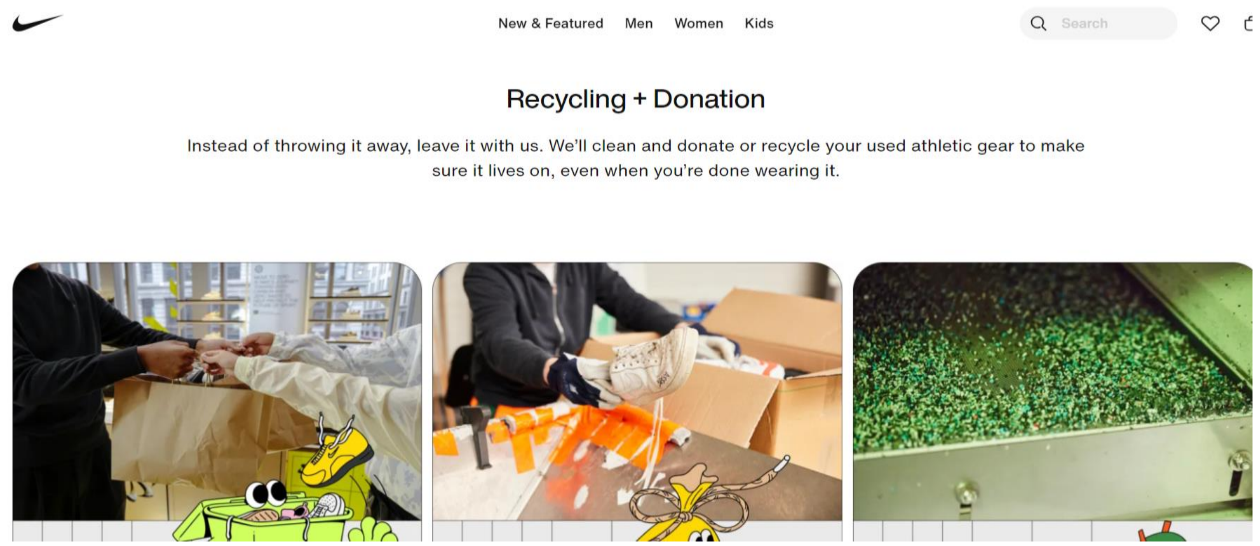

Figure 68. *Source: https://www.nike.com/pt/en/sustainability/recycling-donation*

Conducting the life-cycle assessment (LCA) of its products allowed the teams inside the 76-year-old French Alps ski and outdoor company (Salomon) to know the environmental impact of each step in the product creation process, from the sourcing of materials all the way to the product end of life management. The LCA work is directly informing the global climate strategy of Salomon with science-based data. Solomon new shoe INDEX.02 it is 100% recyclable and features vast improvements performance-wise over its predecessor. Its unique construction allows it to be disassembled at the end of its life so that the shoe materials can be recycled and used to make a new product. There is even a subtle line along the shoe showing where it will be split when it is recycled. A QR code on the tongue of one shoe allows you to easily scan it and register it after purchase, making it easy to return it for recycling at the end of its life.

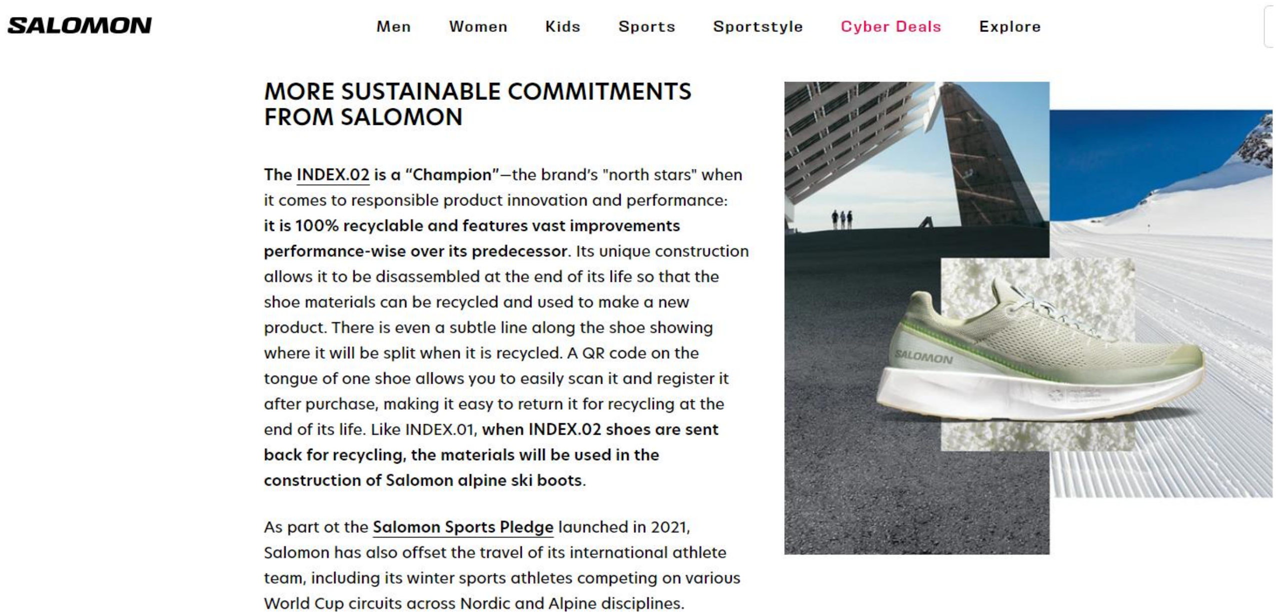

Figure 69. *Source: https://www.salomon.com/en-us/winter-sports-life-cycle-assessment*

The Canadian brand Allbirds develops a program focused on reducing gradually it´s shoes carbon footprint. One of the areas of improvement in its Circular Supply Chain Management strategy is innovation in sourcing, searching and introducing new materials with lower carbon footprint and always searching to replace petroleum-based synthetic materials with natural alternatives whenever possible.
Besides that Allbirds is trying to minimize the amount of material in use in the first place to create lighter products, so we're working to redesign packaging and eliminate manufacturing waste. And in the spirit of fewer, better things, the brand aims to keep products in use longer, so continues to think how can give them new life in their end of life.

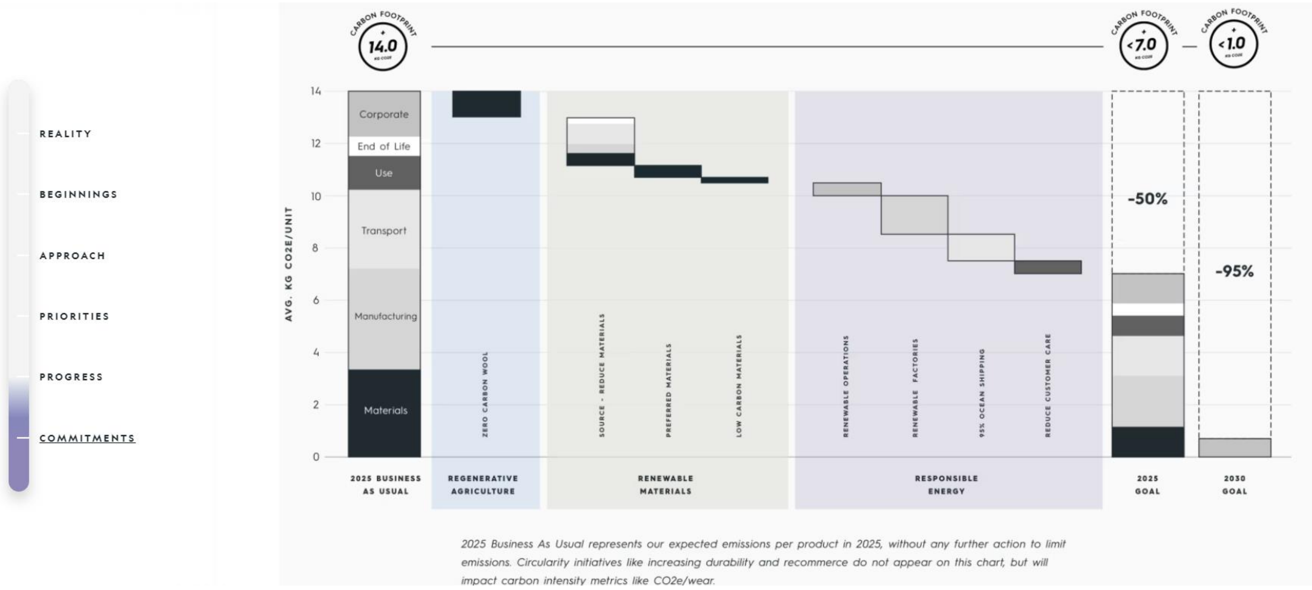

Figure 70. *Source: https://www.allbirds.com/pages/how-we-operate*

The purpose of Patagonia's Supply Chain Environmental Responsibility Program is to measure, reduce and eliminate the environmental impacts of manufacturing Patagonia products and materials. The program is implemented at supplier facilities all over the world and cover a broad range of impact areas, including environmental management systems, chemicals, water use, water emissions, energy use, greenhouse gases, other air emissions and waste.

***Figure** 71. Source: https://www.patagonia.com/our-footprint/supply-chain-environmental-responsibility-program.html*

The Portuguese brand Lemon Jelly defined a Circular Supply Chain supported by footwear made essentially with partially recycled materials, footwear that in the end of his life can be totally recycled and integrated in manufacturing process. With this strategy, Lemon Jelly is able to reduce waste in its process and reduce the need of new materials.

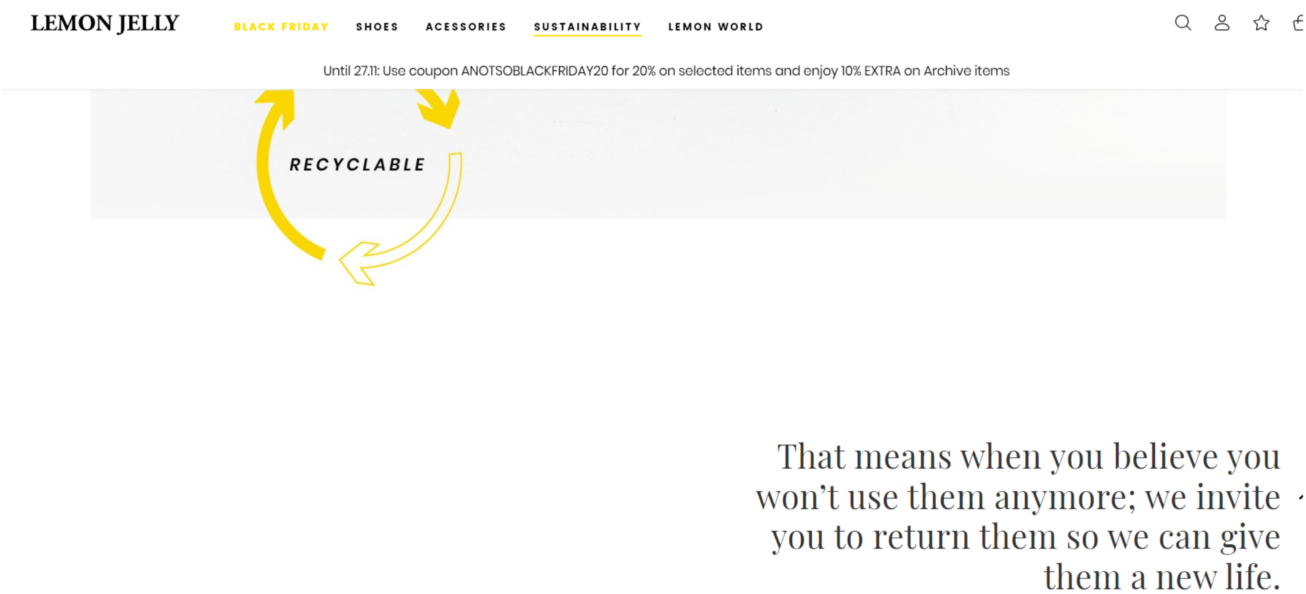

***Figure 72.** Source: https://www.lemonjelly.com/en/sustainability/closing-the-loop_698.html?cbid=2578&cbida=1*

LECTURE 6
PROCEDURES AND TOOLS AVAILABLE FOR A RESEARCH AND DEVELOPMENT MANAGEMENT SYSTEM

6.1. INTRODUCTION

To develop solutions for a brighter future, sustainability must be intertwined with innovation and development. Using sustainability as a guiding principle is vital in research and development (R&D). Sustainable development, as defined by the United Nations, involves meeting the needs of the present without compromising the ability of future generations to meet their own needs.
R&D activities often have direct or indirect impacts on the environment and society. By integrating sustainability into R&D practices, we can protect essential resources for current and future generations, advance social and economic equity, and contribute to global efforts to combat climate change and protect biodiversity.

6.2. INTEGRATING SUSTAINABILITY IN R&D

Our industrial economy is currently rooted in a linear model of resource consumption that follows a ‘**take-make-dispose**’ pattern.

Companies extract materials, apply energy and labour to manufacture a product, and sell it to an end consumer—who then discards it when it no longer serves its purpose.

Even if there has been a lot of individual and institutional measures taken to improve resource efficiency, our current system, based on consumption of resources, entails **significant losses all along the value chain.**

Figure 73. *Plastic wastes.*
Source: https://sensiba.com/resources/insights/the-importance-of-sustainability-in-rd/

How do we change this?

New solutions supported in integrating sustainability criteria in research and development of new products and processes. The triple bottom line is a concept that measures business success not only in terms of **financial performance** (the traditional "bottom line") but also in terms of **social and environmental performance**. The three "bottom lines" of the triple bottom line are people (social), planet (environmental), and profit (economic). **people, planet, profit framework**

In this sense, this **can be seen as a more holistic approach to sustainable business**, as it emphasizes that social and environmental considerations are not separate from economic considerations but are interconnected and should be considered together.

Figure 74. *People, Planet, Profit framework.*

Source: https://jdmeier.com/people-planet-profit/

New materials, processes and products are developed supported on R&D procedures. The integration of Sustainability as a major criterion and a basic purpose in R&D processes is essential to obtain gradual and disruptive gains in Sustainability, considered in its main pillars: Planet, People and Profit.

Prioritizing sustainability in R&D and innovation is a way to maximize the sustainability of products and offerings while minimizing costs, resources, and labour.
To maximize the probability of success, firms should take these critical considerations into account:
Assess sustainability in the **concept design phase** — not after
Establish harmonized processes to optimize the product simultaneously for **function, usability, value, and sustainability**.

- It is crucial to broaden the scope of sustainability and better integrate it into the R&D phase of product development, rather than addressing it as an afterthought.
- Companies must go beyond merely developing products which are more sustainable when in use; additionally, organizations must also improve the sustainability of how they source, manufacture, distribute and sell products.

The development of a sustainability strategy implies the use of a holistic approach inside the company evolving different departments and integrating information and actions from procurement, operations, production, customer service, sales, marketing, technology and equipment. This internal and external cooperation is strategy oriented with project goals.

Figure 75. *Integrating R&D with Business units.*

Source: https://www.lek.com/insights/sus/us/ei/make-products-more-sustainable-incorporate-sustainability-fully-rd

6.3. INNOVATION MANAGEMENT SYSTEM

Integrating Sustainability in R&D implies also to be focused on efficiency and effectiveness but having in mind that innovation prepares us for the future. Thus, the balanced combination of effectiveness, efficiency and innovation will define sustained development.
The key question is how to become an innovative organization without compromising the efficiency, effectiveness, revenue, margins, and profitability of the company.
The use of an Innovation Management System can better support R&D activities providing focus on sustainability considering environment, social and economic goals.

The innovation capabilities of an organization include the ability to understand and respond to changing conditions of its context, to pursue new opportunities, and to leverage the knowledge and creativity of people within the organization, and in collaboration with external interested parties.
An organization can innovate more effectively and efficiently if all necessary activities and other interrelated or interacting elements are managed as a system.
An innovation management system guides the organization to determine its innovation vision, strategy, policy, and objectives, and to establish the support and processes needed to achieve the intended outcomes.

Management system standards complement each other but can also be used independently.
ISO 56000 family of standards, includes several standards and the most relevant are:

- ISO 56000 Innovation management — Fundamentals and vocabulary provides essential background for the proper understanding and implementation of this document.
- ISO 56002 - Innovation management — Innovation management system — Guidance.
- ISO 56003 - Innovation management — Tools and methods for innovation partnership — Guidance.
- ISO 56004 - Innovation management assessment — Guidance provides guidance for organizations to plan, implement and follow-up on an innovation management assessment.

These standards are complementary and can be implemented together with other management system standards, helping organizations to balance the exploitation of existing offerings and operations, with the exploration and introduction of new offerings. Organizations can find a balance between innovation management guidance and other management system standards.

According to ISO 56002 Standard the stages of an innovation management system are: Set Goals, Cooperation, Evaluation of Ideas, Testing and Assessing Innovation Lifecycle. These stages assure that innovation is focused on clear objectives that are in accordance with market context and that company´s resources of R&D are used more effectively and minimizing waste of resources.

Figure 76. *Stages of an innovation management system according to ISO 56002 Standard. Source: https://iso-docs.com/blogs/iso-concepts/innovation-management-iso-56002*

Set Goals – Innovation begins with an objective or necessity. It can be trying something that was never done before or finding the solution to a problem.

Cooperation – Create a culture of sharing information across teams so that everyone has access to all relevant information when they need it.

Evaluation of Ideas – Once the ideas are framed, choose the best ones through brainstorming sessions.

Testing – Once the best ideas have been developed, it is time to put them into action to identify any pain points.

Assessing Innovation Lifecycle – While executing an idea, closely monitor and set milestones to track the progress. Any changes, if required, need to be implemented, or the ideas need to be stopped.

6.4. RELEVANCE OF INNOVATION IN IMPROVING SUSTAINABLE PRACTICES

Integration of R&D and sustainability can be made according to the main strategic focus and objectives of the company. To develop an integrated sustainable strategy companies should act improving sustainable performances in:

- Process
- Product

In process and product, R&D must act in accordance with company`s focus topics or materiality, for instance, Greenhouse Gas emissions reduction, Circular Economy, Waste reduction, Water use reduction, Social Compromises and others.

Integration of R&D and sustainability must act on Products, Materials and Technology seeking, less impact on every stage of the life cycle od the product from selection of materials, provenience, manufacturing process until it´s end of life taking into account social, environmental and economic aspects. Develop new sustainable products, minimizing the environmental impact throughout the product's life cycle, without compromising performance, functionality, quality, safety, ergonomics and costs.

Figure 77. *Products, Materials and Technology. Source: ctcp*

Eco design can be defined as the integration of environmental aspects into product design and development, with the aim of reducing adverse environmental impacts throughout a products lifecycle and should be applied at an early stage. Regarding the specifics of the internal actions that need to be taken, ***eco-design*** is fundamental because a correct design at the beginning will allow a product to be disposed of properly at the end of its useful life. Changing the supply of raw materials is the next step because using bio-based materials will reduce the impact on other eco-systems much as the “reuse, recycle, recovery” of products already used can be re-introduced into the market to favour a multi-loop model.

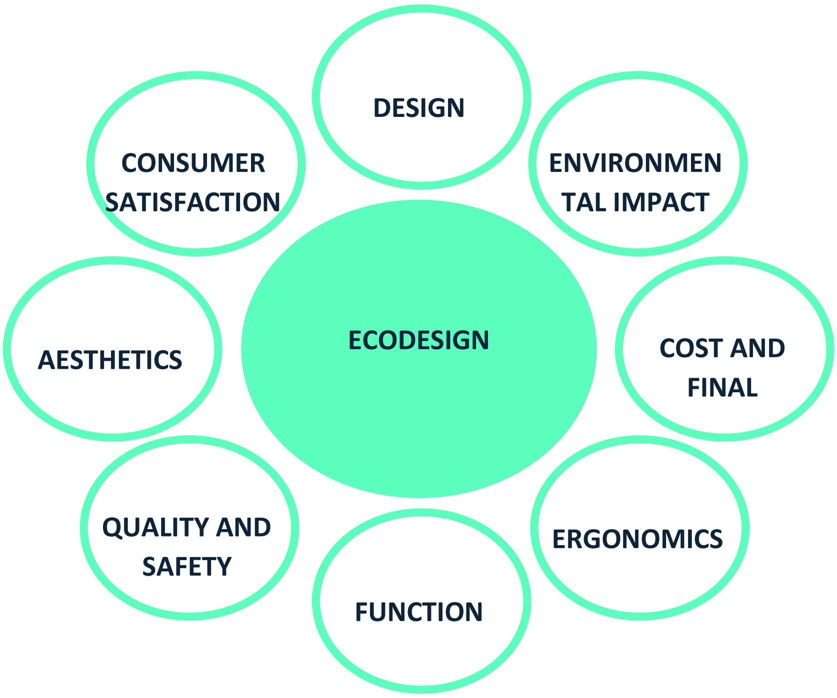

Figure 78. *Dimensions of the eco-design. Source: https://www.greenshoes4all.eu/*

Innovation must consider several critical aspects to develop new more sustainable products – we can consider nine aspects: Design for sustainability, select low impact materials, Reduce materials and components usage, Avoid potentially hazardous substances, Optimize Production techniques, Use low impact packaging.

Figure 79*. Critical aspects to develop new more sustainable products. Source: https://www.greenshoes4all.eu/*

Innovation must also consider several critical aspects to develop new more sustainable products – the last three aspects: more efficient distribution, optimise the use phase, optimise the end-of-life.

Figure 80. *Critical aspects to develop new more sustainable products. Source: https://www.greenshoes4all.eu/*

As part of the Circular Fashion Framework, has identified **sixteen key principles** to support a more circular and sustainable fashion industry. These principles are an example of basic criteria to integrate sustainability with research and development giving different options to an innovation management system in the development of products and processes:

- Principle 1: Design with a purpose
- Principle 2: Design for longevity
- Principle 3: Design for resource efficiency
- Principle 4: Design for biodegradability
- Principle 5: Design for recyclability
- Principle 6: Source and produce more locally
- Principle 7: Source and produce without toxicity
- Principle 8: Source and produce with efficiency
- Principle 9: Source and produce with renewables
- Principle 10: Source and produce with good ethics
- Principle 11: Provide services to support long life
- Principle 12: Reuse, recycle or compost all remains
- Principle 13: Collaborate well and widely
- Principle 14: Use, wash and repair with care
- Principle 15: Consider rent, loan, swap, second-hand or redesign instead of buying new
- Principle 16: Buy quality as opposed to quantity

Figure 81. *Source: https://design4circle.eu/*

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MODULE 5. PART ONE
MARKET AND CONSUMERS' BEHAVIOUR IN THE CIRCULAR ECONOMY

BY **JEAN FRANÇOIS VERMONT** AND **MARIANNA MAGLARA MORNEAU**
CEDECS - CONSEIL POUR LE DÉVELOPPEMENT EUROPÉEN DE L'ENTREPRENEURIAT ÉCOLOGIQUE, CIVIQUE ET SOCIAL – LABORATOIRES D'AFFAIRES POUR LE TEXTILE ET L'HABILLEMENT

Co-funded by
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Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

LECTURE 1
CIRCULAR BUSINESS MODELS: HOW THEY IMPACT CONSUMER BEHAVIOUR

1.1. INTRODUCTION

Unsustainable production and consumption patterns are the main causes of environmental deterioration, with economic activities deteriorating the environment through resource use and waste production. The traditional linear economy, characterized by the "take-make-dispose" model, has contributed to environmental degradation and resource depletion. Circular business models present a compelling solution, promoting a more sustainable approach to production and consumption.

Circular economy becomes as a sustainable alternative to this traditional linear economic model within the fashion industry, including the footwear industry that has negative environmental & social impacts. Circular business models, CBM, aim to close the loop in the product lifecycle, reducing waste and environmental impact by promoting the reuse, refurbishment, and recycling of products. This lesson explores the impact of circular business models on consumer behaviour, focusing on how these models influence consumer choices, perceptions, and attitudes towards sustainable consumption.

Background

The circular economy business model has become increasingly popular to create sustainable businesses, since the concept of a circular economy could help to solve challenges such as resource scarcity and climate change reducing the consumption of natural resources and increasing the recycling of materials and products within the economy (**Tunn et al. 2019**).[48]

More precisely, the circular economy supports the transformation of the linear consumption model into a closed-production model, so that production and consumption waste is reused and incorporated into the economy to create more value, while encouraging the economic activities that reduce, reuse and recycle materials in production, distribution and consumption processes. Therefore, the circular economy aims to keep products, components, materials, and energy in circulation to continue increasing and maintaining their value over a long period of time, which involves changes in the traditional business models.

[48] Tunn, Vivian S., Nancy M. Bocken, Ellis A. van den Hende, and Jan P. Schoormans. 2019. Business models for sustainable consumption in the circular economy: An expert study. Journal of Cleaner Production 212: 324–33

A sustainable business model can change production and consumption patterns, defining how a company develops business and shapes the company–consumer relationship. For this purpose, companies could follow the circularity model, adopting a closed-loop system where resources are returned to the natural environment after use. The concept of circularity is often examined from a business and production model, and researchers are beginning to explore the role of the consumer in closed production models (Wang et al. 2018)[49], highlighting the low consumer awareness and interest in a circular economy (Sijtsema et al. 2020)[50] or reporting the circular attributes perceived as favorable by consumer businesses (Stein et al. 2020).[51]

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.**

The European Union produces more than 2.2 billion tonnes of waste every year. It is currently updating its legislation on waste management to promote a shift to a more sustainable model known as the circular economy.

In practice, it implies **reducing waste** to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible thanks to recycling. These can be productively used again and again, thereby **creating further value**.

This is a departure from the traditional, *linear* economic model, which is based on a take-make-consume-throw away pattern. This model relies on large quantities of cheap, easily accessible materials and energy. Unlike the traditional linear economic model based on a 'take-make-consume-throw away' pattern, a circular economy is based on sharing, leasing, reuse, repair, refurbishment and recycling, in an (almost) closed loop, where products and the materials they contain are highly valued.

In practice, it implies reducing waste to a minimum. Moving towards a more circular economy could deliver opportunities including reduced pressures on the environment; enhanced security of supply of raw materials; increased competitiveness; innovation; growth and jobs. However, the shift also poses challenges such as financing; key economic enablers; skills; consumer behaviour and business models; and multi-level governance.

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49 Wang, Yacan, Benjamin T. Hazen, and Diane A. Mollenkopf. 2018. Consumer value considerations and adoption of remanufactured products in closed-loop supply chains. Industrial Management and Data Systems 118: 480–98

50 Sijtsema, Siet J., Harriete M. Snoek, Mariet A. van Haaster-de Winter, and Hans Dagevo. 2020. Let's Talk about Circular Economy: A Qualitative Exploration of Consumer Perceptions. Sustainability 12: 286.

51 Stein, Nicole, Stefan Spinler, Helga Vanthournout, and Vered Blass. 2020. Consumer Perception of Online Attributes in Circular Economy Activities. Sustainability 12: 1914

The circular economy is a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. It is based on three principles:

5. Eliminate waste and pollution

6. Circulate products and materials (at their highest value)

7. Regenerate nature

As per the Ellen MacArthur Foundation circular economy principles promote minimizing or eliminating waste and pollution, maximizing products and materials use, and regeneration of natural systems (EMF, 2020)[52]. The circular economy system diagram, known as the butterfly diagram, illustrates the continuous flow of materials in a circular economy. There are two main cycles – the technical cycle and the biological cycle.

Various approaches, known as R-strategies, have been developed to reduce resource and material consumption in value chains and make the economy more circular (Morseletto, 2020). The technosphere side of the CE "butterfly diagram" model proposed by the Ellen MacArthur Foundation outlines the circular strategies hierarchy by priority: reuse, repair, refurbish, remanufacture, repurpose, and recycle (Ellen MacArthur Foundation, 2013). More recently, four additional Rs were incorporated into strategies now known as 10Rs, three (reduce, rethink, and refuse) of which are prioritized from a circularity perspective based on smarter product manufacturing and use, while the fourth (recovery) has the lowest priority and is considered less beneficial than recycling (Morseletto, 2020; Reike et al., 2018)[53]

[52] Ellen Mac Arthur Foundation website. The butterfly diagram.

2.1. [53] Piero Morseletto, Targets for a circular Economy, Resources, Conservation and Recycling Volume 153, February 2020, 104553

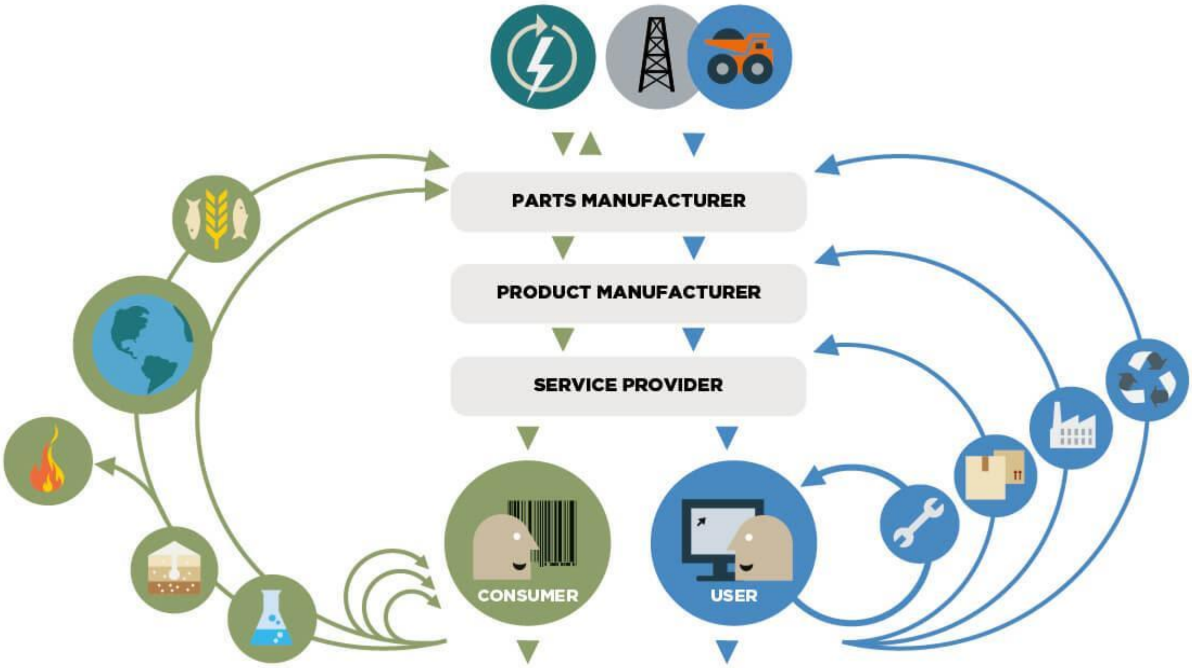


***Figure 1.** Butterfly diagram, Ellen MacArthur Foundation*

The 9R strategies framework

The 9R's are a circular economic framework examines how materials can be used and reused at their highest value while minimizing waste and environmental destruction.
They are Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover. The data was organized according to the framework by Potting et al.[54], in which the 10R are structured into three groups: a) useful application of materials; b) extend lifespan of products and their parts; and c) smarter product manufacturing and use.

Smarter product use & manufacture	R0	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1	Rethink	Make product use more intensive (e.g through sharing products or by putting multi-functional products on market
	R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources

54 Potting, José; Hekkert, M.P.; Worrell, E.; Hanemaaijer, Aldert (2017) Planbureau voor de Leefomgeving, issue 2544 Circular Economy: Measuring Innovation in the Product Chain

Extend Lifespan of product & its parts	R3	Reuse	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function
	R4	Repair	Repair and maintenance of defective product so it can be used with its original function
	R5	Refurbish	Restore an old product and bring it up to date
	R6	Remanufacture	Use parts of discarded product in a new product with the same function
	R7	Repurpose	Use discarded products or its part in a new product with a different function
Useful application of materials	R8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9	Recovery	Incineration of material with energy recovery

***Figure 2**. The 9R's or 10R's strategy, Source: Targets for a circular economy, Piero Morseletto, Institute for Environmental Studies (IVM), Faculty of Earth and Life Sciences, VU University Amsterdam, De Boelelaan 1087, HV, Amsterdam, the Netherlandsfrom Potting et al. (2017) – colours modified".*

Key role of consumers

According to Kirchherr et al. (2017), the circular economy is "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development. It is enabled by novel business models and responsible consumers." (Kirchherr et al., 2017, p. 229[55]) Although this definition includes consumers and consumption processes, it stops short of providing a detailed explanation of what circularity means for consumption and the role of consumers. Circular business models differ in how they influence consumption patterns and consumers. On the one hand, companies can offer alternatives to high impact products and services that do not require a change in consumption behaviour.

However, significant changes in consumer behaviour are required to achieve a successful transition to a circular economy. To make the switch to a circular economy, businesses will need to do more than just develop new circular products and services. They will need to make significant efforts to alter consumer behaviour for consumers to adopt sustainable products and services correctly and effectively.

[55] Kirchherr, Julian, Laura Piscicelli, Ruben Bour, Erica Kostense-Smit, Jennifer Muller, Anne Huibrechtse-Truijens, and Marko Hekkert. 2018. Barriers to the circular economy: Evidence from the European Union (EU). Ecological Economics 150: p229

Consumers are playing a key role for a successful transition towards circular economy. And business models need to educate, influence, and impact all segments of consumers and reply to their needs and expectations.

1.2. CIRCULAR BUSINESS MODELS

Circular business models & related concepts

A circular economy favors activities that preserve value in the form of energy, labour, and materials. This means designing for durability, reuse, remanufacturing, and recycling to keep products, components, and materials circulating in the economy.

1. Product-as-a-Service is a critical business model to enable the circular economy transition. It offers a tangible opportunity for companies to reduce their dependence on new resources and achieve their sustainability goals.
2. Sharing Economy: a business model that promotes collaboration among users to increase the usage and value derived from products. It is based on the sharing of human and physical resources, such as creation, production, distribution, trade and consumption of goods and services. Matching demand and supply effectively. A multitude of new sharing economy platforms are changing consumption patterns and environmental concerns, empowering consumers to capitalise on their property and skills, by using them more efficiently. Reducing the environmental impact of consumption and changing the ownership scheme.
3. Closed Loop systems: an economic model in which no waste is generated; everything is shared, repaired, reused, or recycled.
4. Remanufacturing: Remanufacturing offers an approach to extend product lifetime beyond its first use. After restoring products to original quality, they are reintroduced to the market and Refurbish : Restor a product and bring it up to date
5. Cradle to cradle design: it is a design framework that seeks to create systems that are waste free. This makes products “circular” and reduces their environmental impacts.
6. Recycling: involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. [56]
7. Waste to value: Creating value from waste as a resource.

[56] https://circulareconomy.europa.eu/platform/en/news-and-events/all-news/citizen-awareness-engagement-and-circular-behaviour-online-survey-share-your-experience-ecesp

1.3. CONSUMER BEHAVIOUR PERCEPTIONS & CONCERNS

Consumer behaviour perceptions & concerns for a purchasing choice

Circular business models challenge the conventional concept of ownership, promoting access to goods and services over ownership. Through case studies, we explore the rise of collaborative consumption platforms, such as bike-sharing and fashion rental services, and their impact on consumer behavior and attitudes towards ownership.

Ownership	Budgets & Price	Lifestyle and fashion trends	Functionality and ergonomics	Manufacturin g materials	Sustainability concerns

Figure 3. *Consumer behaviour perceptions & concerns for a purchasing choice*

Consumer Behaviour influencing factors

Consumer behaviour is an important psychological attitude towards circular behaviours. The individual behaviour attitude or the collective attitude of a community has an important role in influencing circular behaviour. The collective attitudes can affect society and can even influence the regulating authority towards enforcing regulations and can also lead a movement towards circular behaviour (Muranko, Andrews, Chaer, & Newton, 2019)[57]. Education, communication, and economic factors have a major impact on the behaviour of the population towards the adoption of circular economy at all levels (Aras & Crowther, 2009)[58]

- Psychological & societal factors
- Key influence factors for a consumption choice

Key psychological & social factors of consumer decision making

Consumer behaviour is influenced by various psychological and societal factors. Circular business models align with consumer values, aspirations, and social norms, driving the adoption of circular consumption patterns.

- **Psychological Factors** relate to the consumer's motivation, learning, socialization, attitudes, and beliefs.

2.2. [57]Zaneta Muranko [a], Deborah Andrews , Issa Chaer , Elizabeth J. Newton Journal of Cleaner Production Volume 222, 10 June 2019, Pages 499-510

[58]G. Aras, D. Crowther Making sustainable development sustainable Management Decision, 47 (6) (2009), pp. 975-98.

- **Societal & social factors** pertain to the influence of culture, social class, family, and reference groups.

Education: Education has a direct effect on consumer behaviour and attitude and decision making for a purchasing final choice. Education is related to knowledge; information and it affects the perception of the consumers and their attitude towards the environment and other social causes. Knowledge acquired also affects what they buy and how they perceive the value.
Cultural factors: Consumer behaviour is driven through cultural ideologies. A consumer is often influenced by their culture, social class and peer groups.

Key influence factors of consumer decision making

Other key factors influencing consumer decision making and choice. Besides consumers' attitudes, other factors can also influence people's openness towards circular business models and activities (Edbring et al., 2016; Lawson et al., 2016;)[59] (Neunhoeffer & Teubner, 2018;)[60] Keirbilck & Rousseau, 2019)[61]. Financial aspects and price clearly matter. The value, pricing & quality of products influence the consumers behavior as well. Some of them are the following:

- Price & budget considerations
- Convenience
- Eco-labelling
- Emotional appeal

Further, the social community is very important for status products and products that connect people and communities. Consumption decisions are influenced by the consumer's desired image and lifestyle. Some circular businesses, therefore, make a conscious effort to create a brand community through Facebook groups, discussion forums, second hand markets (such as Patagonia) and merchandise.

1.4. IMPACT ON CONSUMER BEHAVIOUR

Circular business models aim to create a closed-loop system, where resources are continually reused, recycled, and regenerated, thereby minimizing waste, and reducing the environmental impact.
Tunn (Tunn et al., 2019) explored business models for sustainable consumption in the circular economy context and identified four business model elements of particular interest, because of their

[59] Edbring, E.G., Lehner, M., & Mont, O. (2016). Exploring consumer attitudes to alternative models of consumption: motivations and barriers. Journal of Cleaner Production, 123, 5-15

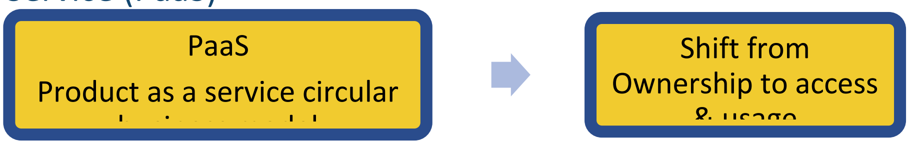
[60] Neunhoeffer, F., & Teubner, T. (2018). Between enthusiasm and refusal: A cluster analysis on consumer types and attitudes towards peer-to-peer sharing. Journal of Consumer Behaviour, 17(2), 221-236

[61] Keirsbilck, B. & Rousseau, S. (2019). The marketing stage: fostering sustainable consumption choices in a "circular" and "functional" economy. In Keirsbilck, B. and Terryn, E. (eds). Consumer protection in a circular economy. Intersentia (Mortsel, Belgium), p.93-126

influence on the sustainability of the consumption side. These four elements are Resource Strategy, Revenue Model, Consumer Effort, and Objective to Decrease/Increase Consumption Level. Companies can, for example, purposefully design products and services to decrease consumption levels. They can design durable, upgradable products that do not become obsolete prematurely (Bakker et al., 2014)[62] but they can also go beyond this by designing systems that enable consumers to use less resources to fulfil their needs. To potentially achieve wide consumer acceptance, circular offerings cannot only compete with their sustainability proposition but need to offer additional benefits such as convenience (Tunn et al., 2019)[63].

Major circular business models adopted by footwear companies has an impact on consumer behavior & choice. They can raise awareness for environmental issues, pollutions & waste and they can reply sometimes to the strong consumers expectations for eco-conscious products. Indeed, on one hand, CBM needs to reply to the needs and consumers expectations for quality, price, safety and durability and to other hand, educate them and communicate upon new models, news roles to play and news ways to share and consume through new consumption patterns living ownership model and encouraging usage through different innovative models.

Product-as-a-Service (PaaS)



The Product-as-a-Service model is centered around providing footwear as a service rather than a product. Consumers can lease or rent footwear for a specific period, returning it when they no longer need it. Footwear companies retain ownership of the products and are responsible for repairing, refurbishing, and redistributing them to other customers.

This model encourages companies to design durable and long-lasting products, which not only reduces waste but also shifts the consumers' focus from ownership to usage through shoes leasing & subscription models.

The major impact is related to the ownership scheme, but it has a direct impact as it contributes to increase awareness of environmental issues towards consumers. The carbon footprint and use of natural resources.

- Increased awareness of environmental issues
- Shift from ownership to access & usage

[62] Mathieux, A., Bakker, C., & Van Arem, B. (2019). Design for circular economy in the footwear industry: A review. Journal of Cleaner Production, 208, 737-751.

[63] Tunn, Vivian S., Nancy M. Bocken, Ellis A. van den Hende, and Jan P. Schoormans. 2019. Business models for sustainable consumption in the circular economy: An expert study. Journal of Cleaner Production 212: 324–33

- Altered brand loyalty.

Remanufacturing & refurbishing circular business model impacts consumer behaviour

Remanufacturing & Refurbishing circular business model

Quality assurance
Price incentives

Remanufacturing and Refurbishing Circular Business Model in footwear industry. Companies engage in remanufacturing and refurbishing processes, where used shoes are collected, disassembled, and repaired to be resold as good as new.
This practice extends the lifespan of footwear, decreases the need for new production, and diverts products from landfills.
Impact on Consumer behaviour: Consumer gains confidence, can pay in lower price and has the satisfaction that he contributes actively to the circular economy.

- Quality assurance
- Price incentives
- Psychological satisfaction

4.3 Second Hand Markets how to impact consumer behaviour

Second-Hand Markets & plateforms

Shift Towards Sustainable Consumption patterns

Circular business models influence consumers to adopt more sustainable consumption patterns. Circular business models have popularized the concept of footwear resale and rental platforms. Consumers can now buy or rent pre-owned shoes, giving them a more affordable and sustainable option to access high-quality footwear. These platforms also promote a circular economy by keeping products in use for longer periods, reducing the demand for new items.

4.4. Extended Producer Responsibility (EPR) & Take-back initiatives: how to impact consumer behaviour

Extended Producer Responsibility(EPR) & Take-Back

Heightened awareness

Product Take-Back Initiatives: Many circular footwear brands implement take-back programs, encouraging consumers to return their old shoes at the end of their life cycle.
- Heightened awareness
Circular business models create awareness among consumers about the environmental impact of their consumption habits. As companies promote their sustainable practices and transparently

communicate their efforts, consumers become more conscious of the choices they make while purchasing footwear. As companies promote their sustainable practices and transparently communicate their efforts, consumers become more conscious of the choices they make while purchasing footwear.

Material Recycling and Regeneration Circular Business Model

Material Recycling and Regeneration → Shift from unsustainable to ethical consumer choice & behaviour

Circular footwear companies use sustainable and recyclable materials, making it easier to repurpose footwear at the end of its life. Recycling initiatives can convert used footwear into raw materials for new products or regenerate them into different forms, reducing the reliance on natural resources.
Impact on Consumer Behavior: Consumer ethical & sustainable choice, eco-conscious behavior

- Conscious material choices
- Ethical consumerism
- Sense of contribution

1.5. CHALLENGES & BARRIER

Figure 4. *Challenges &barrier for adoption circular consumer behaviour*

Transitioning to circular business models is not without obstacles. The challenges faced by businesses and consumers alike in adopting circularity, are infrastructure limitations, behavioral barriers, and regulatory challenges.

1. Consumer resistance & behavioral inertia: The non acceptance of recycled products can be an important barrier as consumers can resist to use recycled products because of low knowledge about their production, image & safety issues. Their role is crucial. The acceptability of circular products depends on consumers' participation and awareness, and the only way to change these is through education and attitude aspects. Some people are

susceptible to psychological or physical barriers such as contamination or responsibility barriers (Hazée et al., 2017)[64]. Using products others have used is a barrier for them.

2. High initial costs & investment challenges. Barriers are financial, structural, operational, attitudinal, and technological.
3. Regulatory Hurdles & policy support. Policies in an economic environment play an important role in the adoption of sustainable methodologies. It is achieved sometimes by incentivizing innovative approaches or by enforcing regulations. Policies can encourage an ecosystem, where businesses collaborate towards innovative alliances and promote environmental concerns.

1.6. FUTURES PERSPECTIVES

As Spring and Araujo (Spring and Araujo, 2017)[65] suggest, in line with the definition of circular consumption, products are 'objects with a career' or 'assemblages of materials' that are stabilised and then transformed by consumers. In a circular economy, consumers would be expected to perform a series of behaviours that enable circular consumption. They are playing an active role in the transition towards circular economy.

Existing research on consumption of solutions that are considered circular such as Product Service, sharing economy, collaborative consumption and remanufactured products provide input on different elements influencing consumer acceptance and adoption. In a recent overview of such elements as presented below a revision of such findings, based on additional research (Camacho Otero et al., 2019)[66].

Factors of acceptance of circular offerings in the fashion sector
Demographic: Age, Gender, Education, Location
Economic: Savings, Transaction, costs, Hygiene and health, Personal liability, Trust in the provider
Psychosocial: Attitudes, Attachment, Behaviour (acquisition, use and disposal) Materialism, Nostalgia, Environmental Values, Subjective norms, Past experiences, Integrity
Cultural: Experience, Experimentation, Social interaction, Fashion involvement, Desire for change and uniqueness Identity, Status, Political consumerism
Socio-material conditions: Impact on everyday life, Ease of use, Legal issues, Technology, Location

Figure 5.*Factors of acceptance of circular offerings in the fashion sector*

[64] Hazée, S., Delcourt, C., & Van Vaerenbergh, Y. (2017). Burdens of access: understanding customer barriers and barrier-attenuating practices in access-based services. Journal of Service Research, 20(4), 441-456

[65] Martin Spring, Luis Araujo, 2017,

[66] J.; Tunn, V.S.; Chamberlin, L.; Boks, C. Consumers in the circular economy. In *Handbook of the Circular Economy*; Brandão, M., Lazarevic, D., Finnveden, G., Eds.; Edward Elgar Publishing Limited: Cheltenham, UK; Northampton, MA, USA, 2020; pp. 74–87.

Another element to take into consideration is the kind of consumer and a segmentation of its profile to be related and engaged towards circular business models on the footwear industry.
Consumer behavior segmentation is a crucial aspect of circular business models in the footwear industry. A circular business model aims to promote sustainability by reducing waste and extending product lifecycles. Understanding different consumer segments and engaging with them effectively is essential for the success of such models.

Eco-conscious Consumers (green materials, eco-labels, repair, recycling, take back initiatives)	**Budget-Conscious Consumers** (highlight the durability and potential cost saving over time, propose rental services and incentives..) savings	**Fashion-Forward Consumers** **(**design with repairable, upgradable components, using influencers to highlight the circular footwear design)
Technology Enthusiasts (tech savvy consumers, incorporate technology to the footwear, innovation for showcases ..)	**Health and Comfort Seekers** (customization options that cater individual needs, for foot health & comfort)	**Community-driven consumers** (events, workshops on sustainability, share success stories on circular footwear..)

Figure 6. *Consumers segmentation*

We can define some profiles and the engagement can be different for its category.

1. **Eco-conscious Consumers:** Consumers that prioritize sustainability and environmentally friendly products. They are willing to pay more for products that align with their values. The engagement with them passes through eco-friendly materials used in the footwear and the sustainable production processes, clear commitment to environmental causes and any certifications or eco-labels and an offer of recycling programs for old footwear and the concept of returning used shoes to be refurbished or recycled.
2. **Budget-Conscious Consumers or value seeking consumers:** This segment has price & budgeting concerns and looks for affordable options but may be willing to choose sustainable products if the value is clear. For an engagement with them arguments of long-term cost-effectiveness of circular footwear, the durability and potential cost savings over time could be good ones. Flexible payment options, such as leasing or rental services, making sustainable footwear more accessible to a wider audience.
3. **Fashion-Forward Consumers:** This segment is interested in trendy and stylish footwear. They may not be primarily driven by sustainability, but they can be convinced to embrace circular models through design footwear with a focus on current fashion trends while incorporating circular principles, such as easily repairable or upgradable components, collaboration with popular fashion influencers or celebrities to endorse your circular footwear and create buzz around your products and limited editions.

4. **Technology Enthusiasts:** Tech-savvy consumers are intrigued by innovative solutions and the integration of technology. To engage with them just needed to incorporate technology into the circular footwear, such as smart insoles that monitor foot health or customizable components based on digital foot scanning and leverage social media and online platforms to showcase the technological advancements.
5. **Community-Driven Consumers:** This segment seeks a sense of belonging and wants to be part of a larger movement. Engaging with them will be easier with a community around the circular footwear brand that will hosting events, workshops, or online forums centered on sustainability and circular economy topics. Sharing success stories and testimonials from satisfied customers who are contributing to the circular economy through their purchase decisions.
6. **Health and Comfort Seekers:** This segment values comfort and foot health. Ergonomic design and sustainable materials used in the footwear, customization options that cater to individual foot needs and the health benefits of wearing sustainably produced shoes could be a good argument to engage with them.
7. **Quality Driven consumers:** This segment is looking for durability and high-quality footwear to reduce the frequency of replacements. The engagement passes through repair services, warranties, or extended product guarantees.

Shifting Consumer perspectives & behaviour

1. Becoming eco-conscious & integrating environmental concerns on their choices: educating consumers on the benefits and importance of circular products
2. Brand loyalty based on values, ethics & sustainability: empowering consumers to embrace circular practices.
3. Preferences on circular products designed for Repair & Reuse & by Recycling materials: empowering & enabling consumer behavior driven by circular business.

Insights for future circular consumers patterns

Figure 7: Insights for future circular consumers patterns

1.7. CONCLUSION

Circular business models have the potential to revolutionize the footwear industry and significantly impact consumer behaviour. By promoting eco-friendly materials, encouraging durability, and fostering a second-hand market, circular models drive consumers towards more eco-conscious & sustainable choices.

Consumers must play a critical role. Consumer awareness, further education and brand loyalty create a more environmentally conscious consumer behaviour. As the circular business models continue to progress, they will play a key role in shaping the future of the footwear sector towards a more sustainable and circular economy.

LECTURE 2
COMMUNICATIONS & MARKETING STRATEGIES FOR CIRCULAR ECONOMY : MESSAGING & BRANDING

2.1. INTRODUCTION

A recent study of the European Commission confirmed that "studies and surveys show that European consumers often lack the basis they need to make informed choices". As a result, even if they wish to, they are not capable of rewarding those companies that embed sustainably in their business models or company policy (BEUC 2020)[67]. So far, communication for circular economy issues has been mainly conducted through labels such as the Cradle-to-Cradle design principle or the EU Ecolabel. It is now widely acknowledged that transparent and intelligible communication implemented through innovative approaches should lead consumers towards purchasing choices that are in line with circular economy principles. This need has been addressed in the EU's Circular Economy Action Plan (CEAP) that foresees the need to empower consumers in the field of adequate consumer information in order to enable them to participate in the circular economy (European Commission 2020b).

In an era where sustainability and responsible consumption are paramount, the circular economy has emerged as a promising solution to address the environmental and social challenges posed by traditional linear economic models. Communication and marketing play pivotal roles in promoting and advocating for the adoption of circular economy principles.

The shift towards sustainable and circular economies is crucial in addressing the environmental challenges. The footwear industry, like many others, is increasingly embracing circularity to reduce waste, conserve resources, and mitigate its environmental footprint. Effective communication and strategic branding play pivotal roles in shaping consumer perceptions and driving the adoption of sustainable practices within this sector. Marketing and communication for the circular economy are essential to raise awareness, drive adoption, and create a positive impact on sustainability. The circular economy is an economic model focused on minimizing waste and making the most of resources, and it relies on effective marketing and communication strategies to educate, engage, and inspire various stakeholders.

Background

The circular economy has become increasingly popular to create sustainable businesses, since the concept of a circular economy could help to solve challenges such as resource scarcity and climate

[67] European Commission (2018). Behavioural Study on Consumers' Engagement in the Circular Economy (et al. A., Porsch, L., Suter, J. (ed.)).

change, reducing the consumption of natural resources and increasing the recycling of materials and products within the economy (**Tunn et al. 2019**).[68]
The circular economy supports the transformation of the linear consumption model into a closed-production model, so that production and consumption waste is reused and incorporated into the economy to create more value, while encouraging the economic activities that reduce, reuse and recycle materials in production, distribution and consumption processes. Therefore, the circular economy aims to keep products, components, materials, and energy in circulation to continue increasing and maintaining their value over a long period of time, which involves changes in the traditional business models.

The circular economy involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.**
In practice, it implies reducing waste to a minimum. This shift also poses challenges such as financing; key economic enablers; skills; consumer behaviour and business models; well informed consumers and multi-level governance.

Communications & Marketing strategies key role

Consumers need to be aware of all circular economic principles.
According to Kirchherr et al. (2017), the circular economy is "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development. It is enabled by novel business models and responsible consumers." (Kirchherr et al., 2017, p. 229[69]) Although this definition includes consumers and consumption processes, it stops short of providing a detailed explanation of what circularity means for consumption and the role of consumers. Circular business models differ in how they influence consumption patterns and consumers. On the one hand, companies can offer alternatives to high impact products and services that do not require a change in consumption behaviour.

However, significant changes in consumer behaviour are required to achieve a successful transition to a circular economy. To make the switch to a circular economy, businesses will need to do more

[68] Tunn, Vivian S., Nancy M. Bocken, Ellis A. van den Hende, and Jan P. Schoormans. 2019. Business models for sustainable consumption in the circular economy: An expert study. Journal of Cleaner Production 212: 324–33

[69] Kirchherr, Julian, Laura Piscicelli, Ruben Bour, Erica Kostense-Smit, Jennifer Muller, Anne Huibrechtse-Truijens, and Marko Hekkert. 2018. Barriers to the circular economy: Evidence from the European Union (EU). Ecological Economics 150

than just develop new circular products and services. They will need to make significant efforts to alter consumer behaviour for consumers to adopt sustainable products and services correctly and effectively.

Communications & marketing strategies with **messaging & branding** should play a key role for a successful transition towards circular economy in order to educate, influence, and impact all segments of consumers and reply to their questions and expectations.

The global fashion industry, particularly the footwear sector, faces significant challenges in sustainability and environmental impact. The emergence of the circular economy paradigm presents an opportunity to revolutionize how we design, produce, market, and consume footwear sustainably. Effective communication and marketing strategies within the circular economy framework, focuses on messaging and branding in the footwear industry to interact with consumers. The footwear industry has a substantial environmental footprint due to its reliance on raw materials, manufacturing processes, and waste generation. Circular economy principles advocate for resource efficiency, waste reduction, and the continual use of materials in a closed loop. In the context of footwear, this involves designing products for durability, reusability, and recyclability, while minimizing waste and environmental impact. This lesson explores the role of communications & marketing strategies for circular economy: messaging & branding.

2.2. COMMUNICATIONS & MARKETING STRATEGIES

Identifying target audience & stakeholders

Identifying and segmenting target audiences for circular economy initiatives.
Tailoring messages based on audience preferences, demographics, and psychographics.
The psychological factors are used in product communication to persuade consumers to buy circular products. SHIFT framework (White et al., 2019)[70]. The implementation of tailored communication & marketing campaigns to appeal to environmentally conscious consumers, demonstrate the brand's dedication to sustainability.

Crafting compelling narratives & cases studies

One of the methods used by businesses consists of sharing success stories and case studies of businesses or individuals that have successfully adopted circular practices. These real-world examples can inspire others and influence consumer’s behaviour as well. **Craft compelling narratives** that highlight the environmental and economic benefits of circular solutions.

[70] White et al., 2019

Storytelling & visuals

Another impactful method is the use of storytelling & visuals: Leveraging Storytelling & Visuals to enhance engagement & understanding.

Effective storytelling can **emotionally connect consumers** to the brand's sustainability journey. Personal narratives and compelling stories about sustainable practices in the footwear industry can resonate with consumers and **influence their purchasing decisions**.

Clear and compelling communication emphasizes the environmental advantages such as durability, repairability, and recyclability of circular footwear.

***Figure 8**. Content Messaging*

2.3. BRANDING STRATEGIES

Principles of strategic brand identity for circular footwear

Branding is a powerful tool for promoting circular economy values and distinguishing a brand within the footwear market. Circular footwear brands should focus on aligning their brand image with sustainability, quality, and innovation.

The alignment of the brand values with circular economy principles, reflects commitment to circularity and responsibility.

The visual Representation is the second step: sustainable imagery and colour schemes, evoking a sense of eco-friendliness and environmental consciousness.

Shifting Consumer perspectives & behaviour through messaging & branding

1. Becoming eco-conscious & integrating environmental concerns on their choices: educating consumers on the benefits and importance of circular products
2. Brand loyalty based on values, ethics & sustainability: empowering consumers to embrace circular practices.

3. Preferences on circular products designed for Repair, Reuse & by Recycling materials: empowering & enabling consumer behaviour driven by circular business.

Figure 9. *Insights for circular consumers behaviour*

Shifting Consumer perspectives & behaviour through messaging & branding

1. 1.Becoming eco-conscious & integrating environmental concerns on their choices: educating consumers on the benefits and importance of circular products
2. 2.Brand loyalty based on values, ethics & sustainability: empowering consumers to embrace circular practices.
3. 3.Preferences on circular products designed for Repair, Reuse & by Recycling materials: empowering & enabling consumer behaviour driven by circular business.

Communication on circular practices

Consumer behaviour is an important psychological attitude towards circular behaviours. Education, communication, and economic factors have a major impact on the behaviour of the population towards the adoption of circular economy at all levels (Aras & Crowther, 2009)[71].

Sustainable Branding Elements

1. Integrating sustainability & circularity into **brand logos**, **packaging, and product design** reinforces the brand's commitment to circular economy principles. Incorporating eco-friendly materials, earth tones, and recycling symbols in branding elements visually communicates the brand's dedication to sustainability. Consumers and stakeholders often value transparency regarding product life cycles, materials used, and sourcing.
2. **Labels & certifications**: Leveraging certifications, Labels are strong symbols to communicate credibility & transparency. The communication of circular and sustainable attributes of products through national labels and certificates has culminated in the **EU Ecolabel** which was established in 1992 (European Commission 2020b). It certifies products that meet sustainability and circularity criteria throughout their entire life cycles, making sure that products and their manufacture produce as little carbon dioxide as possible, are durable, easy

[71]G. Aras, D. Crowther Making sustainable development sustainable Management Decision, 47 (6) (2009), pp. 975-98

to repair and can be readily recycled. The label acts as a communication instrument for the Circular Economy Action Plan, helping consumers to make a purchasing decisions that support the creation of circular economy (European Commission, 2020a)[72]. Another example is **Cradle to Cradle** certification which specifically focuses on products that are designed.

3. **Circular Packaging**: Designing and implementing sustainable, recyclable packaging solutions that align with circular economy principles, demonstrating a brand's commitment to reducing waste and its impact on the environment.
4. **Repair, Recycle, Reuse Programs**: Showcasing repair, recycle, and reuse programs that allow customers to return old footwear for refurbishment, recycling, or repurposing, encouraging a circular consumption cycle

Building trust

Promoting **transparency** regarding sourcing, manufacturing, and **environmental impacts** reinforces confidence in consumers through detailed information on the materials used, production processes, and initiatives to reduce waste and carbon footprint, demonstrating accountability and building trust.
Transparency in Supply Chains: Promoting transparency regarding sourcing, production, and supply chains to install trust and confidence in consumers. Clearly communication on the brand's sustainability efforts and partnerships.
Further, the social community is very important for status products and products that connect people and communities. Consumption decisions are influenced by the consumer’s desired image and lifestyle. Some circular businesses, therefore, make a conscious effort to create a **brand community** through Facebook groups, discussion forums, second hand markets (such as Patagonia) and merchandise.

Design innovation & Product differentiation

Innovative and appealing product designs that integrate circular principles can distinguish a brand in the market. Brands need to showcase how their designs prioritize circularity without compromising style and comfort.

Collaborations & Partnerships

Partnerships with peers: Collaboration with other businesses, NGOs, governments, and academia amplify the message of the circular economy and drive collective action towards sustainability.
Presentation of **Showcase successful partnerships** to demonstrate the impact of collaborative efforts. Indeed, partnerships with other sustainable brands, organizations, or environmental advocates can enhance a brand's credibility and influence. Collaborations amplify the reach of

[72] European Commission, 2020b, (https://ec.europa.eu/environment/ecolabel/) accessed 18 December 2020.

sustainability messages and present a united front for a circular economy. Consumers' behaviour can be influenced through those channels.

2.4. DIGITAL MARKETING INNOVATIVE APPROACH

Circular economy principles aim to create a closed-loop system, where resources are continually reused, recycled, and regenerated, thereby minimizing waste, and reducing the environmental impact.

In today's digital age, leveraging social media and online platforms is vital to reach a broader audience: the use of innovative marketing techniques such as augmented reality (AR) or virtual reality (VR) to showcase the circular lifecycle of products and services.

Different methods and ways to privilege:

- social media platforms to disseminate information about the circular economy, sharing news, insights, and success stories to engage a wide audience,
- user-generated content and participation through relevant hashtags, challenges, and campaigns.
- Creation & distribution of engaging content, such as blog posts, articles, infographics, videos, and podcasts, that explain the circular economy and how individuals and businesses can participate.
- Nudges consumers as well. Nudging is an approach that changes people's behaviour by altering the decision-making environment to influence people's decisions when choosing on what to act. Its implementation must be easy, cheap, and not mandatory (Thaler and Sustein, 2008)[73]. This approach can be used as well to inform and influence consumers. For instance, green nudges are used to complement environmental, food and bioeconomy policies towards more sustainable and circular production systems.

Digital platforms, innovative tools

Augmented Reality or Virtual Reality

Augmented reality (AR) refers to a technology that adds virtual elements to the real world. These virtual elements can appear in the form of text, images, 3D models or animations, for example. They are usually displayed via a smartphone or special AR glasses. AR can be used for various purposes, such as marketing, education, navigation or training.

[73] Richard H. Thaler, Cass R. Sunstein, Nudge, Improving decisions about health, wealth & happiness Yale University Press, 1 janv. 2008

Virtual reality (VR), on the other hand, refers to a technology that creates a virtual world that users can enter with the help of VR glasses. In a VR environment, the user can interact, manipulate objects and even perform physical movements. This allows him to interact with the virtual world. VR can be used for various purposes, such as gaming, simulations, training, or therapy.

The main difference between AR and VR is that AR adds virtual elements to the real world. VR creates a completely virtual environment that users can immerse themselves in. AR is more of a supplement to the real world; VR provides a fully immersive experience in a virtual world.
And the Mixed Reality (MR) where virtual elements are embedded in the real world and can be interacted with by the user as if they were present in the real world. This technology offers even more possibilities for applications in various fields.
An example of a company using VR and AR technology to promote circularity business is Patagonia. The company uses AR technology to guide customers through virtual tours of its value chain and showcase the company's sustainability practices including sustainability.

Engagement strategies

Strategies for engaging & educating audiences through social media
Among different ways to interact & inform consumers incorporate gamification elements into marketing campaigns to engage and educate the audience on circular economy principles is one.

Online tools

Circular brands create online platforms that connect consumers, businesses, and organizations focused on the circular economy, creating a hub for information and collaboration.

Measures & impacts

Circular business models create awareness among consumers about the environmental impact of their consumption habits. As companies promote their sustainable practices and transparently communicate their efforts, consumers become more conscious of the choices they make while purchasing footwear.

As companies promote their sustainable practices and transparently communicate their efforts, consumers become more conscious of the choices they make while purchasing footwear.
Measure & report on the environmental & economic impact of circular practices within the organization to build credibility & demonstrate progress.
Regularly measure and report on the environmental and economic impact of circular practices within the organization to build credibility and demonstrate progress.

2.5. SAMPLES OF MESSAGING

Another element to take into consideration is the kind of consumer and a segmentation of its profile to be related and engaged towards by using different messages on the footwear industry. Consumer behaviour segmentation is a crucial aspect of circular business models in the footwear industry. A circular business model aims to promote sustainability by reducing waste and extending product life cycles. Understanding different consumer segments and engaging with them effectively is essential for the success of such models.

Extend the Life of Products: Repair, Reuse, Recycle!	Closing Loops, Opening Opportunities: A Circular Economy for a better Futur
Circularity Begins with You: Sort, Recycle, Repeat!	Choose Reuse, Reduce Waste! Embrace the Circular Economy
One step towards Sustainability: choose Circular Footwear	Our footwear is crafted from recycled and eco-friendly materials, reducing waste and environmental impact

Figure 10. *Sample of messages*

2.6. CONCLUSION

Effective messaging and branding strategies are indispensable for promoting circular economy principles within the footwear industry. Communicating the benefits of circular footwear and integrating sustainability into brand identity can drive consumer awareness, influence purchasing decisions, and contribute to a more sustainable future for the footwear sector. By implementing these strategies, the footwear industry can align itself with the circular economy paradigm, minimizing environmental impact and maximizing resource efficiency.

LECTURE 3
CONSUMER ENGAGEMENT & CIRCULAR ECONOMY: HOW TO ENCOURAGE ADOPTION & BEHAVIOR CHANGE

3.1. INTRODUCTION

A recent study of the European Commission confirmed that "studies and surveys show that European consumers often lack the basis they need to make informed choices". As a result, even if they wish to, they are not capable of rewarding those companies that embed sustainably in their business models or company policy (BEUC 2020)[74]. This need has been addressed in the EU's Circular Economy Action Plan (CEAP) that foresees the need to empower consumers in the field of adequate consumer information to enable them to participate in the circular economy (European Commission 2020b).
In an era where sustainability and responsible consumption are paramount, the circular economy has emerged as a promising solution to address the environmental and social challenges posed by traditional linear economic models. Consumers engagement strategies play pivotal roles in promoting and advocating for the adoption of circular economy principles & behaviour change.

Overview of the footwear industry & consumer engagement

The circular economy supports the transformation of the linear consumption model into a closed-production model, so that production and consumption waste is reused and incorporated into the economy to create more value, while encouraging the economic activities that reduce, reuse and recycle materials in production, distribution and consumption processes. Therefore, the circular economy aims to keep products, components, materials, and energy in circulation to continue increasing and maintaining their value over a long period of time, which involves changes in the traditional business models and to consumer behaviour as well.
The circular economy involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.**
The footwear sector is notorious for its unsustainable linear consumption model. It involves resource-intensive production, high waste generation, and limited end-of-life recycling. Millions of shoes are discarded each year, leading to environmental problems such as pollution, landfill waste, and resource depletion. To combat these issues, a transition to a circular economy within the footwear sector is crucial. Encouraging consumer engagement in the circular economy is essential in driving positive change within this sector.

[74] European Commission (2018). Behavioural Study on Consumers' Engagement in the Circular Economy (et al. A., Porsch, L., Suter, J. (ed.)).

Consumers behaviour drivers & barriers

Consumers need to be aware for all circular economic principles.

According to Kirchherr et al. (2017), the circular economy is “an economic system that replaces the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It is enabled by novel business models and responsible consumers.” (Kirchherr et al., 2017, p. 229[75]) Although this definition includes consumers and consumption processes, it stops short of providing a detailed explanation of what circularity means for consumption and the role of consumers. Circular business models differ in how they influence consumption patterns and consumers. On the one hand, companies can offer alternatives to high impact products and services that do not require a change in consumption behaviour.

However, significant changes in consumer behaviour are required to achieve a successful transition to a circular economy. To make the switch to a circular economy, businesses will need to do more than just develop new circular products and services. They will need to make significant efforts to alter consumer behaviour for consumers to adopt sustainable products and services correctly and effectively.

One of the most important drivers and simultaneously a barrier for consumer engagement is the price in the Circular Economy, followed by convenience.

Other drivers are: Providing consumers with more and better information about the durability of products; designing products with better Circular Economy credentials; and widening the offer of repair services from manufacturers and retailers.

At the same time, the major barriers towards consumer engagement are:

- consumers’ lack of knowledge.
- the absence of reliable information about durability/reparability features of a product.
- high cost of repair services; and consumers’ lack of trust in repair service.

Consumer engagement plays a pivotal role in the transition to a circular economy in the footwear sector. Educating and motivating consumers to adopt sustainable practices and change their behaviours is key. Several strategies can be employed to achieve this objective. This lesson explores the strategies and mechanisms to encourage consumers to adopt circular practices and change their behaviours in the footwear industry.

[75] Kirchherr, Julian, Laura Piscicelli, Ruben Bour, Erica Kostense-Smit, Jennifer Muller, Anne Huibrechtse-Truijens, and Marko Hekkert. 2018. Barriers to the circular economy: Evidence from the European Union (EU). Ecological Economics 150: p229

3.2. CONSUMERS BEHAVIOUR FACTORS

Consumers' willingness for engagement

Identifying and segmenting consumers for circular economy initiatives. Consumer behaviour is an important psychological attitude towards circular behaviours.

The individual behaviour attitude or the collective attitude of a community has an important role in influencing circular behaviour.

Education, communication, and economic factors have a major impact on the behaviour of the consumer toward the adoption of circular economy principles. All strands of research demonstrated that consumers were generally willing to consider the durability and reparability of products when purchasing new products.

A recent EC study 'Behavioural Study on Consumers' Engagement in the Circular Economy Final Report Prepared by LE Europe, VVA Europe, Ipsos, ConPolicy and Trinomics, October 2018[76] provide us with some indications on consumers' motivations & willingness to engage in the Circular economy because they care for the environment. The focus groups furthermore highlighted that being able to save money was another key motivator for purchasing more durable products. Some key findings are the following:

- Most respondents claimed to be aware of the durability of the products they purchased (64%) as well as of repair services (58%). Respondents also indicated that they frequently searched for durability and reparability information of products (62% for durability and 55% for Reparability.
- Most respondents (93%) reported that they kept things they owned for a long time, recycled unwanted possessions (78%), and repaired possessions if they broke (64%). Respondents furthermore felt that their peers (close friends and family) displayed similar levels of engagement in CE practices.
- Some of the surveys conducted found that consumers are, to some extent, willing to change their lifestyle to address sustainability issues. Some previous studies as well as interviews with stakeholders have documented **that consumers are willing to pay for products with better environmental credentials**. Yet, the French CREDOC for example reported that consumers could be reluctant to adopt more sustainable purchasing choices. Other experts have highlighted that survey research needs to be interpreted with caution as there might be a discrepancy between what people say about their CE behaviours and what they do.
- Generally, there is agreement that Circular Economy decisions **depend on a trade-off between price and other considerations (such as e.g. quality, convenience, caring for the environment, being good at repairing.** Consumers may find it difficult to assess whether

[76] Behavioural Study on Consumers' Engagement in the Circular Economy Final Report, Prepared by LE Europe, VVA Europe, Ipsos, ConPolicy and Trinomics., October 2018

repairing a product would be worthwhile, whether refurbished or second-hand products presented good value for money. Such uncertainty can lead consumers to purchase brand new products instead, especially, when the price difference between new and second hand, or refurbished products is not substantial.

- Regarding product-specific willingness to engage in the CE, according to the literature, stakeholders and focus groups, durability and reparability were seen as most important for large, more expensive and less fashion-dependent products such as white goods. Instead, these CE credentials were seen as less important for fashion and technology items which are replaced more frequently. At the same time, consumers can become attached to fashion items, especially clothing, which then makes them reluctant to replace items and opt for repair instead.
- **For fashion products there was a higher willingness to buy second hand** (clothes, smartphones), or to rent or lease such products (smartphones).
- A minority, yet still sizable share, of survey respondents were interested in engaging with novel CE practices such as leasing products instead of purchasing them. The share of respondents who would be willing to lease a product rather than purchase it was lowest for vacuum cleaners (10%) and highest for smartphones (25%). These relatively low levels of interest may have been partly driven by general unfamiliarity with such practices. Yet, taking into consideration that leasing practices are novel, there seems to be a sizable market potential currently untapped by leasing.

This study helps us as well to understand that the issues to consider are in the majority the information & education path of consumers, the trust for reparability & the shift towards more sustainable & circular behaviours.

Consumer engagement to Circular Economy principles

One of the major priorities is how to align consumer engagement to circular principles related to footwear industry such as: Think to Recycle, Rethink, repair and reuse, waste minimisation, objective zero waste through education, online communities, collaborations, reparability services.

Figure 11: Circular Economy Principles

3.3. CONSUMERS ENGAGEMENT STRATEGIES

Encouraging consumer engagement and behaviour change in the footwear sector to embrace a circular economy involves a multi-faceted approach that includes education, incentives, convenience, and collaboration. The circular economy aims to keep products and materials in use for as long as possible through reuse, repair, and recycling.

Raising Awareness through Education & information

One of the fundamental ways to encourage consumer engagement towards the circular economy within the footwear sector as in the fashion sector as well is through education and awareness campaigns. Consumers need to be informed more about the environmental impact of traditional footwear production and the benefits of adopting circular practices. Campaigns dedicated to highlight the potential outcomes, such as reduced waste, decreased pollution, and conservation of natural resources.

For instance, Schools and Universities engagement programs:

a. **Sustainability and circular economy** concepts **into school and university curricula**, promoting responsible consumption from an early age.
b. **Research and projects related to circular footwear** design and consumption among students.

Incentives & Rewards through new policies for sustainable choices

Governments, manufacturers, and retailers are asked to implement various incentives to motivate consumers to choose sustainable footwear options. This can include tax incentives for purchasing recycled or upcycled footwear, discounts for returning old footwear for recycling, or loyalty programs encouraging long-term use and recycling of shoes.

More specifically some practices are:

a. **Discounts for Trade-ins**: Offering discounts or store credit to customers who trade in their old shoes for new ones, encouraging the return of shoes for recycling or refurbishment.
b. **Reward Programs**: Implement loyalty programs that incentivize consumers to return used footwear for recycling or participate in repair workshops.

Product Design & innovation through circular business models

Incorporating durability and longevity into footwear design is crucial to align consumer behaviour with the principles of a circular economy. Manufacturers start to prioritize creating products that last longer, resist wear and tear, and can be easily repaired or refurbished. Encouraging consumers to invest in high-quality, durable footwear and providing repair services can foster a culture of longevity, reducing the overall environmental footprint associated with frequent replacements.
Manufacturers play a significant role in encouraging consumer engagement by incorporating circular principles into product design. Footwear companies start to create durable, repairable, and recyclable shoes. Innovative designs allow for easy disassembly and component replacement can extend the lifespan of footwear, thereby reducing the need for frequent purchases and minimizing waste. The design of the products itself can incentivize a change. Some examples are Véja shoes and N'GO shoes, Zéta…

The major trends:

a. **Design for Disassembly:** Footwear manufacturers are asked to design products that are easy to disassemble, repair, and recycle.
b. **Extended Producer Responsibility (EPR):** Advocate for legislation that holds footwear manufacturers responsible for the end-of-life management of their products, encouraging them to design for durability and reuse.

We can do a reference as well to EU legislation promoting circular economy principles, which are particularly relevant to the footwear industry's environmental challenges: EU Waste Framework Directive[77] and the Circular Economy Action Plan[78] that both contribute to set targets and guidelines for waste management, recycling, and resource efficiency.

Take-Back Programs through Recycling & Reparability Initiatives

For manufacturers or brands establishing take-back programs for old footwear and promoting recycling initiatives are effective strategies to encourage consumers to participate in the circular economy. Footwear companies can offer discounts or incentives to customers who return their old shoes for proper recycling and repurposing. These programs should be easily accessible and widely

[77] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en
[78] https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

promoted. For the moment recycling is not rewarded. The fashion industry and most specifically the footwear industry consumers expected durability to vary according to price and quality. People tend to purchase certain clothing items more often due to changing fashion trends and less for the durability & circular economy impacts.

For instance, Decathlon has the recycling corner where you can deposit old footwear without reward. Veja has the reparability corner. Repairable shoes have higher quality construction than regular shoes and feature better stitching as well as stronger components such as leather uppers, rubber outsoles and stronger laces. Repairable footwear is those that are designed with restoration in mind.

a. **Collection Points:** collection points in retail stores, recycling centers, or public places where consumers can easily drop off their old shoes for recycling or repurposing.
b. **Mail-in Recycling Programs**: Pre-paid shipping labels or arrange for mail-in recycling programs, allowing consumers to send their old shoes for recycling without any additional cost.

Examples of take back programs: Adidas: The **adidas Choose to Give Back program** is powered by thredUP's Resale-as-a-Service® (RaaS®) and invites consumers to send their used gear back to adidas to be reused or resold. **Timberland** starts to close the loop with new take-back program, Timberloop, in partnership with ReCircled[79]. **Swiss brand On Running** has a recyclable shoe in the works too. They're asking customers to sign up for an innovative shoe subscription with a down payment of $29.99. Thus, consumers never own the shoe itself. Rather they're able to use it for the time needed, and when it begins to wear down, they send it back and it's recycled[80].

Buying shoes that can be refurbished can be an easy step towards reducing our environmental footprint while still looking stylish and staying comfortable.

Figure 12. *Timberland Take Back & Suisse On Running subscription program*

[79] James Roberts, Futurworld, Footwear, Jan25, 2022
[80] Esha Chhabra, This Footwear Brand Wants Your Old Shoes, Forbes.com

Collaborations & Partnerships through durability

Partnerships with peers: Collaboration with other businesses, NGOs, governments, and academia amplify the message of the circular economy and drive collective action towards sustainability.
Indeed, partnerships with other sustainable brands, organizations, or environmental advocates can enhance a brand's credibility and influence. Collaborations amplify the reach of sustainability messages and present a united front for a circular economy. Consumers' behaviour can be influenced through those channels.
Collaborations between footwear companies, waste management organizations, nonprofits associations & organisations, and government bodies amplifies the impact of circular economy efforts. By pooling resources and knowledge, these entities can develop and implement effective strategies to promote circularity in the footwear industry and educate consumers about sustainable choices.

Transparency & Traceability through labels & certifications

Providing consumers with transparent information about the production process, materials used, and the environmental impact of footwear fosters trust and informed decision-making. Implementing traceability mechanisms, such as QR codes or blockchain technology, allows consumers to track the journey of their footwear from production to disposal, promoting responsible consumption.
Better information for consumers on product features may drive their participation in more Circular Economy (CE) practices.
In that sense, labels are useful tools for the information they provide and the trust they create to consumers:

a. **Certification Programs**: Certifications that label footwear based on their sustainability and circularity, allowing consumers to make informed choices.
b. **Transparent Supply Chains**: Footwear companies disclose information about their supply chains, including sourcing, production processes, and end-of-life handling. Nike, Adidas, Veja etc.

Consumer engagement through technology

Online platforms or mobile applications dedicated to circular footwear consumption can foster the engagement of consumers and encourage their behaviours change by providing information on sustainable footwear options, recycling locations, repair services, and second-hand markets. These platforms can act as a hub for the circular economy community, encouraging discussions and sharing success stories.
For instance:

a. **Mobile Apps and Gamification**: Mobile applications that educate consumers on circular economy principles and incentivize sustainable behaviour through gamification and rewards.
b. **Augmented Reality (AR) for Virtual Try-Ons**: Implement AR technology to allow consumers to virtually try on shoes, reducing the need for physical trials and potential returns.

By combining these strategies, the footwear sector encourages consumers to adopt a circular economy mindset, leading to a more sustainable and environmentally friendly industry.

3.4. CONSUMERS TYPOLOGY & TACTICS

Another element to take into consideration is the kind of consumer and a segmentation of its profile to be related and engaged towards by using different messages on the footwear industry.
Consumer behaviour segmentation is a crucial aspect of circular business models in the footwear industry. A circular business model aims to promote sustainability by reducing waste and extending product life cycles. Understanding different consumer segments and engaging with them effectively is essential for the success of such models. Strategies for engaging & educating audiences through social media.
Among different ways to interact & inform consumers incorporate gamification elements into marketing campaigns to engage and educate the audience on circular economy principles is one.
How to engage with the different consumers profiles with different tactics & practices.

***Figure 13**. Different consumers profiles & tactics*

3.5. CONCLUSION

Consumer engagement is crucial in the transition to a circular economy in the footwear sector. By implementing strategies such as more information & awareness, product design, trustful recycling & repairability programs, collaborations, consumer incentives, and engagement platforms, the footwear industry can encourage consumers to adopt more circular practices and change their behaviours. The circular economy presents an opportunity for the footwear sector to reduce its environmental footprint, minimize waste, and contribute to a more sustainable future. By working together, footwear industry stakeholders and consumers can take significant steps towards achieving these goals in the circular economy.

LECTURE 4
CONSUMER ENGAGEMENT & CIRCULAR ECONOMY: HOW TO ENCOURAGE ADOPTION & BEHAVIOR CHANGE

4.1. INTRODUCTION

The fashion industry is one of the most environmentally impactful. It is estimated that about 9% of greenhouse gas emissions are attributable to this industry. It is a highly resource-consuming industry with a rather low recycling rate. At a global level, the figures define an important volume of material and resources consumption: 98 million tons per year of non-renewable resources, 93 billion cubic meters of water, 60% of the textile fibers used are synthetic and, among these, polyester, which is the most widespread, requires, for European consumption, more than 70 million barrels of oil (Ellen MacArthur Foundation, 2017).

The EU is moving towards a climate neutral and circular economy, which means that any product today must be more energy efficient, durable, reusable, repairable and recyclable. The fashion and textile industries, known to have a big impact on the environment, are at the forefront of change and sustainability. Innovative materials created from materials recycled and recycled in the future, new technologies in traditional leather industries, collaborations with environmental experts, and most importantly, complete transparency of the entire chain - these are the main vectors for the development of the shoe industry today.
This lesson analyses new technologies, best practices and innovations that aim to make the footwear industry less impactful and, most importantly, circular.

Overview of the footwear industry Footprint

The concept of a circular economy is gaining increasing attention as societies and businesses grapple with the challenges of resource depletion, environmental degradation, and the growing urgency to combat climate change. In a circular economy, resources are used more efficiently, and waste is minimized through the reintegration of products and materials into the production cycle.
To remind that the footwear industry has a substantial environmental footprint due to its reliance on raw materials, manufacturing processes, and waste generation. Circular economy principles advocate for resource efficiency, waste reduction, and the continual use of materials in a closed loop. In the context of footwear, this involves designing products for durability, reusability, and recyclability, while minimizing waste and environmental impact.

Consumers behaviour

Consumers need to be aware of all circular economic principles.

According to Kirchherr et al. (2017), the circular economy is "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It is enabled by novel business models and responsible consumers." (Kirchherr et al., 2017, p. 229[81]) Although this definition includes consumers and consumption processes, it stops short of providing a detailed explanation of what circularity means for consumption and the role of consumers. Circular business models differ in how they influence consumption patterns and consumers. On the one hand, companies can offer alternatives to high impact products and services that do not require a change in consumption behaviour.

However, significant changes in consumer behaviour are required to achieve a successful transition to a circular economy.

4.2. MAJOR VECTORS IN THE FOOTWEAR SECTOR

There is increasing focus on the need for repair-friendly laws to extend the lifespan of products. There is growing recognition of the need for regulations that tackle the problem of planned obsolescence and promote product repair and reuse. To shift from linear, "take-make-waste" models to a "closed loop" circular economy, where waste and pollution are minimized; products and materials are kept in use for longer; and natural systems are allowed to regenerate.

Examples of circular economy practices include reducing purchases, buying products that are recyclable or made with recycled materials, buying used or refurbished products instead of brand-new ones, repairing and reusing products instead of replacing them, and recycling products instead of throwing them away.

The major vectors are the following:

1. Innovative materials created from materials recycled and recycled in the future, new technologies in traditional leather industries, collaborations with environmental experts, and most importantly, complete transparency of the entire chain - these are the main vectors for the development of the shoe industry today.
2. Materials from completely non-obvious raw materials that companies use.
3. Efforts of all brands towards sustainability and circularity. There are brands that even if they do not use innovative and new environmentally friendly materials, they contribute to the preservation of the planet's environment.

[81] Kirchherr, Julian, Laura Piscicelli, Ruben Bour, Erica Kostense-Smit, Jennifer Muller, Anne Huibrechtse-Truijens, and Marko Hekkert. 2018. Barriers to the circular economy: Evidence from the European Union (EU). Ecological Economics 150: p229

4. Many leading brands are directly involved in the development of new materials and eco-technologies, and in the education of the consumer, encouraging him in an eco-friendly lifestyle.
5. Consumer’s behaviour is another vector that the brands need to take into consideration.

4.3. CASES STUDIES & BEST PRACTICES TO BE INSPIRED

The innovative materials their use and even their fabrication is perhaps one of the most actively developing areas in the footwear industry. Only large brands can develop at a high level and with the possibility of scaling. Sustainability, innovation, Recycled materials, Reuse & Repair strategies, circular business strategies such close the loop, Transparency & ethical issues in the production are the major drivers of the entire market. Showcases as Cucci & Demetra. Adidas with the Three Loop sustainability strategy, Nike with Reuse a shoe, Veja sustainable shoes, Low carbon Footprint initiatives such as Undo for Tomorrow, Suiss On and innovative eco- conscious approach of traditional brands such as Converse initiative.

Innovative Materials & Product Design

CUCCI CASE DEMETRA

A prime example of the use of innovative materials is Gucci's plant-based leather substitute Demetra. It is a new material that is 77% plant-based, a blend of viscose and wood pulp from sustainable forest sources, and bio-based polyurethane from renewable sources. It combines quality, softness, durability, environmental friendliness and - importantly - scalability. Gucci plans to make Demetra available to the entire fashion industry from 2022. It took the company two years of research and development to develop the material.

In addition, the use of non-environmentally friendly components is minimized in new products and ongoing research is underway to replace them. Demetra waste generated during production will be recycled and reused.

Demetra is produced in the Gucci factory in Italy using the same tanning processes as for genuine leather. This allows you to make the material soft, durable, elastic and pliable.

Figure 14. *photo Source: https://www.cucci.com*

The fact that companies are investing in such developments confirms the growing importance of ethical and sustainable practices in the fashion industry.

In addition, the use of non-environmentally friendly components is minimized in new products and ongoing research is underway to replace them. Demetra waste generated during production will be recycled and reused.
Demetra is produced in the Gucci factory in Italy using the same tanning processes as for genuine leather. This allows you to make the material soft, durable, elastic and pliable.
The first products made from Demetra were the Gucci Basket, Gucci New Ace and Gucci Rhyton sneakers - most of the upper and part of the lining are made of this material.

Recycling & Repairability Initiatives

ADIDAS THE THREE LOOP ADIDAS STRATEGY: RECYCLED LOOP

The Three Loop Strategy focuses on the Adidas effort in creating three categories of sustainable production. In 2015, Adidas partnered with Parley for Oceans to create the first-ever running shoe made from recycled plastic waste. From that partnership, they introduced Primeblue and Primegreen performance fabrics. These 100% recycled polyester performance fabrics are unique in being pure on the recycled content. Instead of using virgin polyester or other newly developed material to build the product, Adidas will source raw materials from another available stream that is recycled.
More than 15 million pairs of such shoes were produced. Adidas is constantly expanding its vegan offering and is completely phasing out the use of fur. In collaboration with partners, adidas develops plant-based leathers, recycled cotton, and especially climate-friendly running shoes.

Figure 15. *adidas x Parley source: http://www.adidas.com*

Incorporating durability and longevity into footwear design is crucial to align consumer behaviour with the principles of a circular economy. Manufacturers start to prioritize creating products that last longer, resist wear and tear, and can be easily repaired or refurbished. Encouraging consumers to invest in high-quality, durable footwear and providing repair services can foster a culture of longevity, reducing the overall environmental footprint associated with frequent replacements. However, Adidad has been accused for greenwashing for some of its initiatives.

THE THREE LOOP ADIDAS STRATEGY: CIRCULAR LOOP

Adidas introduced the "Futurecraft LOOP shoe « which represents a pioneering effort in sustainable sneaker production. The key innovation behind this initiative is the creation of a fully recyclable running shoe. By designing the shoe with a single material, TPU (Thermoplastic Polyurethane), and ensuring that it can be easily disassembled, Adidas aims to keep the product within the production cycle, reducing the need for resource extraction and waste generation. This approach encourages consumers to return their worn-out shoes to Adidas, further promoting circularity in the footwear industry.

Figure 16. *adidas Futurecraft Loop Running Shoe source: http://www.adidas.com*

Adidas' circular loop allows them to create products out of single materials like TPU, with the eventual aim of developing new recycling capabilities to take all these used TPU products, recycle them, and reuse the material for new products.

THE THREE LOOP ADIDAS STRATEGY: REGENERATIVE LOOP

Adidas recognises that even by recycling everything and designing products to be remade, it's likely that some of these will not end up back in the loop. That's why their ultimate goal is to make sure these materials can eventually be returned to nature with minimal environmental harm. Adidas has been partnering with companies like Bolt Threads, to make products out of natural materials that can biodegrade:new yarns out of protein that can be engineered for specific purposes.

Last year, the sports brand showcased a biofabric tennis dress at Wimbledon that they'd designed with Stella McCartney. The entire garment was made from this bio fabricated micro silk.

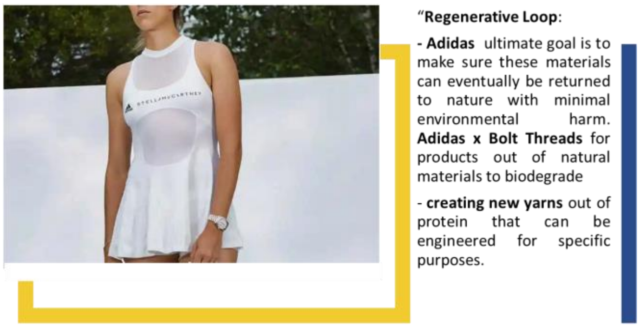


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Figure 17. *adidas x Stella McCartney Biofabric Tennis Dress source: http://www.adidas.com*

NIKE'S "REUSE-A-SHOE"

The program focuses on collecting old athletic shoes from consumers and transforming them into materials for sports surfaces and new footwear. This initiative demonstrates the importance of recycling in the circular economy. One of the pioneering initiatives in the footwear industry's transition towards a circular economy is Nike's Reuse-A-Shoe program: Nike collects old athletic shoes and grinds them into material to create surfaces for sports courts and tracks. Launched in 1993, when Nike opened a basketball court at its distribution center in Wilsonville, Oregon. The surface of the court was made from the resulting material, and it was called the Nike Grind. Since then, the sports brand and partners have recycled more than 60 tons of waste, including 30 million pairs of sneakers, for Nike Grind. Today, Nike Grind grinds a wide range of waste, from excess to out-of-print samples and scrap. The company's mission is to reduce waste wherever possible and reuse it whenever possible. Over the years, Nike Grind technology has been used in completely different areas. As a raw material for artificial turf and soccer balls, for running tracks and soles. It not only reduces waste but also engages consumers in recycling their old shoes. By recycling worn-out shoes and repurposing them into new products, Nike is not only minimizing waste but also reducing the demand for virgin resources.

In addition, the program promotes responsible consumer behaviour by encouraging people to return their old shoes instead of discarding them.

Figure 18. *Source : https://www.nike.com*

Buying shoes that can be refurbished can be an easy step towards reducing our environmental footprint while still looking stylish and staying comfortable.

UNDO FOR TOMORROW – SNEAKERS FROM RECYCLED BALLOONS

Creating materials from recycled waste is also an important area of development. The Portuguese brand Undo for Tomorrow released sneakers made from recycled balloons. The upper of the shoe is made from recycled plastic with a water-repellent finish, making it practical for all weather. The rubber outsole of the sneaker is made from discarded balloons and tire residues, it is non-slip and quite flexible. Shoe lining made of 100% bamboo has an antibacterial effect and absorbs odours.

Figure 19. *Source: https://undofortomorrow.com*

Sustainable production scheme & Transparency

FRENCH VEJA SUSTAINABLE SNEAKERS & N'GO

The French manufacturer of sneakers VEJA, which fully follows the principles of sustainable development in its work. The company uses organic cotton grown by farmers' associations in Brazil and Peru. The method of its cultivation implies care and respect for people and the environment. The company purchases cotton (raw material) rather than finished fabric in a fair-trade manner and predominantly uses only such cotton for the manufacture of its products. Since 2004, VEJA has purchased 195 tons of wild rubber directly from local communities in the Brazilian states, saving 120 hectares of the Amazon Forest. In a shoe company, rubber is used to make the soles of sneakers: they consist of 18% of rubber. The purpose of this eco-campaign is to increase the economic value of the forest for its conservation.

Figure 20. *source: https://veja.com*

The brand focuses on transparency by emphasizing the use of eco-friendly materials and ethical labour practices. Veja has not only appealed to environmentally conscious consumers but also set a standard for ethical footwear production. **Transparent Supply Chains**: Footwear companies disclose information about their supply chains, including sourcing, production processes, and end-of-life handling. Nike, Adidas, Veja etc. Another French sustainable production sneakers are N'GO made in Vietnam. The company from Nantes Britanny France is a B Corp company with responsible supply chain & production scheme (organic cotton, wild rubber, transparency, environmentally friendly). N'GO create schools in Vietnam and work closely with local communities.

Low carbon Footprint

LOW CARBON FOOTPRINT - YY NATION'S NIMBO

YY Nation, a new sustainable footwear brand based in New Zealand's capital, has launched the **Legacy Footwear Collection,** which includes sneakers with the world's lowest carbon footprint, as verified by independent dual certification. Launching a Kickstarter campaign last year to fund its idea, YY Nation successfully met and then quadrupled its fundraising goal, raising over NZ$80 from nearly 985 like-minded people. Now, after three years of research and development, **YY Nation's Nimbo shoes, made from bamboo and algae, have a carbon footprint of 500 kg of carbon dioxide equivalent (CO5,45e), three times less carbon emissions than regular running shoes.**

Legacy Footwear Collection YY Nation's Nimbo

New sustainable footwear brand based in New Zealand's capital, has launched the Legacy Footwear Collection, which includes **sneakers with the world's lowest carbon footprint,** as verified by independent dual certification.

Figure 21. *source: https://yynation.com*

SWISS ON RUNNING - FIRST EVER CARBON EMISSION SHOE

There are also materials from completely non-obvious raw materials. So Swiss sports brand "On" has created **a new foam called Clean Cloud** that turns **carbon emissions into a running shoe sole**. The company has worked with biochemistry, process, and polymer innovators LanzaTech and Borealis on a technology that they believe could be used in other footwear parts and products in the future. On, which claims to be the first company to use carbon emissions as the main raw material for shoe soles, hopes to use the technology in all its shoes over time. The Swiss company is the first in the footwear industry **to use carbon emissions as the primary raw material for the midsole of a shoe.**

Suiss On brand 'Clean Cloud tech'

In collaboration with LanzaTech, Borealis, and Technip Energies, the sportswear brand created the Cloudprime sneaker using carbon emissions as a raw material to reduce the brand's carbon footprint.

Figure 22.*: source : https://www.on-running.com*

ECCO DANISH BRAND WITH ECCO LEATHER'S DRITAN™ - REDUCE WATER IN LEATHER PRODUCTION

Even if the brand does not use innovative and **new environmentally friendly materials**, it always has a chance to contribute to the preservation of the planet's environment. For example, like the Danish ECCO, by reducing the amount of water used in the leather processing process.

Figure 23. *source: https://globalecco.com*

DriTan™ technology saves 600 tons of sludge from reaching landfills per year, and by bringing new life to our byproducts, we are steadily moving closer to our goal of zero waste.

Their goal to increase **water efficiency** in the leather tanning process is a big part of their sustainability mission. **ECCO Leather's DriTan™** technology was developed as a first step towards more water-efficient leather manufacturing, a game-changing production method for the leather industry.

LEGENDARY CONVERSE BRAND & NEW LABS VIRTUAL STORE

Figure 24. *source: https://renewlabs.com*

Converse opened a Renew Labs virtual store on a garbage island in the Pacific Ocean. This island is made up of 80 tons of plastic and covers an area larger than France**. Renew Labs is a hybrid reality** project that allows visitors from all over the world to walk and shop on the trash island. It features a **collection of eco shoes** designed by All Stars, young creators who are concerned about the world's environmental issues. They used technologies **with the least harmful waste**, from innovative to more familiar methods. Funds raised by Converse from **sales of sneakers will be used to pay for the cleanup of the Pacific Ocean and the elimination of garbage.**

Second life Initiatives

DECATHLON CASE: ‘SECOND LIFE’

Decathlon, a big name in the sports market. They’ve been around since 1976 and have both online and physical stores, with 325 shops in France and 1751 worldwide. Their mission? To make sports accessible to all and bring joy to people through sports. But Decathlon is also a front-runner in going green. Decathlon has been exploring **how to turn their old linear business model into a circular one**. They’ve launched a **major initiative called «Second Life»** anchored on three activities: **repairing, renting and re-selling**. They’ve got all sorts of projects going like fixing stuff in their shops and offering spare parts together with DIY videos online. They are renting out gear that you typically don’t use all year round like tents, kayaks or skis and testing a subscription scheme based on your intensity of practice in Belgium. They are also selling second-hand items on shelves, **testing a buy-back scheme for bikes and other durable products, and even letting people recycle in their shops**.

At Decathlon, they have embraced the concept of « sustainable value creation ». It’s built on three pillars: sustainable sales (selling eco-friendly products and services), customer loyalty (keeping folks happy and coming back for more), and reducing their footprint, both environmentally and socially.

Consumers participate in the success of this shift of business model by their engagement and active involvement.

Figure 25. source : https://www.decatlhon.com

4.4. IMPACT ON CONSUMERS’ BEHAVIOUR

Another element to take into consideration is the consumer’s behaviour.

All efforts towards circular & regenerative business models put the accent on the importance of the involvement and awareness of the consumer, which are responsible of the end of life of the products they buy and use. Aware them about the importance of the R-strategies and putting them in condition to extend the life of the products are some of the main steps towards sustainability. Brands put in place new sustainable products & strategies however the consumer is a key actor towards their success of Reuse- Repair – refabrication and Recycling Programs.

Many leading brands, for example, adidas, are not only directly involved in the development of new materials and eco-technologies, but also in the education of the consumer, involving him in an eco-

friendly lifestyle. Adidas is attentive to local markets and collaborates with local influencers and experts in all of its campaigns. And they do it not only to promote their own products, but also to involve as many people as possible in the topic of ecology. So, as part of the Run for the ocean campaign this year, Bulyash Todayeva, an industrial designer, engineer in the field of sustainable development and the founder of the Zerowastelab project, and Alexei Bakhmetiev, a TV presenter known for his upcycle inventions, became brand ambassadors. Together with Bulyash, adidas developed and launched the adidas Telegram chatbot “Kroshka”, which in an accessible form told subscribers about simple household eco-habits and shared tips for a conscious lifestyle. Together with Kroshka, users determined plastic labels from photographs, found the nearest waste recycling and sorting point, received useful information from experts, and got acquainted with the topic of ecology in a fascinating way. Thus, companies are engaged not only directly in the development of new materials, but also in the education of the consumer, involving him in an environmentally friendly lifestyle.
Veja’s purpose of its eco-campaign is to increase the economic value of the forest for its conservation. Consumers are actively participating in its success by choosing this sustainable brand. The success of circular economy initiatives in the footwear industry has a significant impact on consumer behaviour. These initiatives have triggered several changes in consumer attitudes and choices:

- **Increased awareness**: Circular economy initiatives have raised awareness among consumers about the environmental impact of their footwear choices. As a result, more consumers are making informed decisions to support brands with sustainable practices.
- **Shift towards sustainability**: Consumers are increasingly prioritizing sustainability and ethical practices when purchasing footwear. Brands that adopt circular economy principles have gained a competitive advantage and consumer loyalty.
- **Extended product life:** Circular footwear initiatives have encouraged consumers to repair and maintain their shoes instead of disposing of them prematurely. This shift contributes to a reduction in overall waste and resource consumption.

4.5. CONCLUSION

The transition to a circular economy is vital for mitigating the environmental challenges posed by the linear economy model. Case studies and best practices are essential tools for understanding the practical aspects of circular economy initiatives and their impact on consumers behaviour. By highlighting successful cases & best practices such as Nike's Reuse-A-Shoe program, Adidas' collaboration with Parley for the Oceans, and Veja's ethical and sustainable sneakers the footwear industry serves as an excellent example of how circular economy principles can be successfully applied to reduce waste, improve sustainability, and influence consumers behaviour. The success of circular economy initiatives contributes to a broader cultural shift towards responsible consumption. Consumers are increasingly valuing quality over quantity, preferring durable products and favouring brands that take responsibility for their environmental impact.

As sustainability concerns become more and more central to consumer choices, companies that adopt circular economy principles and transparent, ethical production methods are likely to thrive in the future market. The footwear industry showcases how sustainability can be stylish, creating value, and transformative, inspiring other industries to follow & consumers to shift towards sustainable behaviour patterns.

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MODULE 5. PART TWO
MARKET AND CONSUMERS' BEHAVIOUR IN THE CIRCULAR ECONOMY

BY **BARBARA ANNUNZIATA** AND **ANTONELLA MENNA**
CENTRO ITALIANO PER L'APPRENDIMENTO PERMANENTE

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LECTURE 5
PRO-ACTIVELY UNDERSTAND CUSTOMERS AND MARKET NEEDS

5.1. INTRODUCTION

In the dynamic landscape of today's business environment, success hinges not only on the products or services offered but on the profound understanding of the customers who use them and the ever-evolving needs of the market. In this module, it will be delved into the strategic imperative of proactively comprehending the intricate nuances of both customers and market dynamics.
In a world characterized by rapid technological advancements and shifting consumer behaviours, businesses find themselves at a crossroads where anticipation and proactivity are paramount. Reactive strategies, though once effective, are no longer sufficient in meeting the demands of a discerning and ever-connected clientele. The proactive approach, one that transcends the mere fulfilment of existing needs, emerges as the cornerstone of sustainable growth and customer loyalty.
It needs to explore the multifaceted realm of understanding customers proactively. From harnessing the power of data analytics and segmentation to establishing robust feedback mechanisms, this section illuminates the strategies that empower organizations to foresee and fulfil customer expectations before they arise personalized experiences, predictive analytics, and the creation of meaningful feedback loops in crafting a customer-centric paradigm.
Simultaneously, the intricate currents of market dynamics need to be navigated, recognizing that the sands of consumer preferences and industry landscapes are ever-shifting. Through meticulous market research, competitor analysis, and the adoption of emerging technologies, businesses can not only stay afloat but also ride the waves of change to gain a competitive advantage. Industry networking, regulatory awareness, and fostering a culture of innovation as essential elements in proactively addressing market needs.

5.2. UNDERSTANDING NEEDS

A useful glossary

MARKET RESEARCH

Market research concerns the activity of collecting information on the needs and preferences of the relevant public, made up of potential consumers of the product or service under analysis.
By understanding the perception and behaviour of the target consumers, it is possible to adopt the necessary measures to meet their needs, reducing the risks of gaps in the experience, i.e. the

situations in which a gap is created between the expectations that consumers have towards the product or service and the actual offer. Market research also helps to keep up with competitors' offerings, which in turn affects customer expectations with respect to the product/service under consideration. This is an activity that affects all aspects of a business, including brand, products, customer service, marketing, and sales. Market research often focuses on understanding the following elements:

- Customers (current, past, non-customers, influencers)
- The company (product or service design, promotion, pricing, positioning, services, sales)
- The competition (and how its offers interact in the market)
- The sector - as a whole (to understand if it is growing or moving in a certain direction)

Figure 1. *What is market research.*
Source: John Academy (https://www.johnacademy.co.uk/why-is-market-research-important-to-a-business/)

MARKET TRENDS

The term "market trend" refers to the predominant direction or movement in the price behavior of a particular market over time. It indicates the general trend that can be observed on the price charts of a specific asset or sector.

Market trends can be classified into three main categories:

1. **Bullish trend:** it occurs when the prices of an asset or market move constantly upwards, forming a series of rising highs and lows. This indicates a situation of confidence and optimism on the part of investors.
2. **Bearish trend:** it occurs when the prices of an asset or market move constantly downwards, forming a series of decreasing highs and lows. This indicates a situation of mistrust and pessimism on the part of investors.
3. **Sideways trend or range-bound trend**: it occurs when prices move within a narrow price range, with relatively stable highs and lows. This indicates a lack of clear direction in the market and a balance between supply and demand.

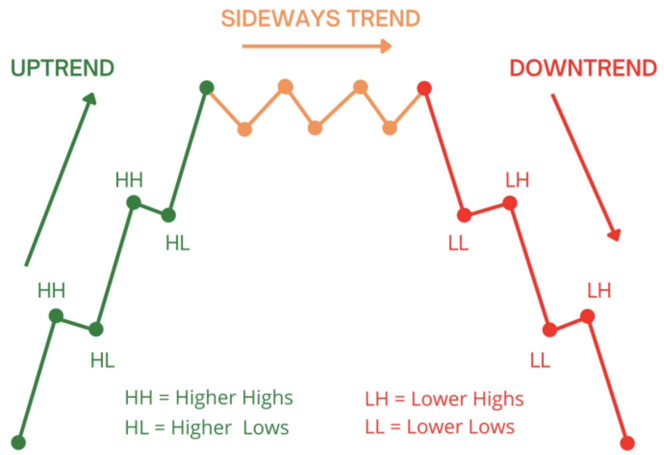


Figure 2. *Market trends. Source: Unger Academy (https://ungeracademy.com/posts/what-are-market-trends-and-how-to-take-advantage-of-them)*

MARKET NEEDS

Market needs refer to the specific requirements, desires, or demands of consumers or businesses within a particular market. These needs represent the gaps or opportunities that exist in the market, which companies aim to address through the development and delivery of products or services. Understanding market needs is crucial for businesses to design and offer solutions that meet customer expectations and provide value.

Market needs can encompass a variety of factors, including functional requirements, emotional desires, and unmet demands. Identifying and fulfilling these needs effectively can contribute to a company's success and competitiveness in the market. Market research and analysis play a key role in uncovering and understanding these needs, allowing businesses to tailor their offerings to better meet the preferences and requirements of their target audience.

Consumer needs are all the shortcomings that a consumer encounters and that push him/her to look for a product on the market in order to satisfy them. Understanding the motivations behind search behaviour offers brands an opportunity to better meet consumer needs.

In constant contact with one device or another, people expect to be assisted everywhere and to receive immediate answers to their needs. The searches consumers do, the sites they visit and the videos they watch don't just express intent, they're reshaping the traditional marketing funnel.

With the help of marketing technology, marketers can sift through all the signals left along this path and gain insights that can help them predict consumer intentions and pick up on the signals that drive long-term growth.

CUSTOMER EXPERIENCE

Customer experience refers to the complex of interactions and emotions that a customer has during the entire journey of interaction with a company. It is the sum of impressions, perceptions and sensations resulting from the various stages of the customer experience, which may include the search for information, the purchase of a product or service, after-sales assistance, and other interactions with the agency. A good customer experience is essential for companies because it can influence customer loyalty, their perception of the brand and the possibility of generating positive recommendations. Companies always try to provide a pleasant, smooth, and personalized experience to meet customers' needs and expectations.

Figure 3. *Using Feedback to Improve Customer Experience in 2023: The Ultimate Guide. Source: https://www.linkedin.com/pulse/using-feedback-improve-customer-experience-2023-ultimate-guide-789qc/*

CUSTOMER SATISFACTION

Customer satisfaction is the degree of customer satisfaction with a product, service and/or company. We talk about customer satisfaction when the customer's expectations, relating to various elements, such as benefits, quality/price ratio, promises made, etc. have been satisfied or even exceeded.

Figure 4. *Consumer satisfaction*

SUPPLY CHAIN

By supply chain we mean the process that allows a product or service to be brought to the market, transferring it from the supplier to the customer. It is therefore a complex process that involves multiple professional figures, activating numerous processes of the business ecosystem: from the

flow of raw materials linked to the production processes, up to the distribution logistics that ensures that the purchased good reaches the customer.
At the same time, the expression supply chain can refer to the more managerial aspects of the distribution chain. In this case it would be more appropriate to use the expression supply management (**SMC chain**), which refers to the coordination activities that serve to optimize the individual links of the supply chain. Supply chain links are the individual stages that make up the supply chain. It is possible to identify three large main phases which can in turn be broken down into smaller processes: procurement | production | distribution.

Figure 5. *Supply chain management.*
Source: https://www.sap.com/products/scm/what-is-supply-chain-management.html

When talking about supply chain it is possible to come across the concept of value chain. The more rings a product passes through, the greater the final accumulated value will be.
So, to better understand the needs of consumers and the market relating to the production of sustainable shoes, a series of factors must be analysed.
Below, there are some actions that are fundamental for understanding the system:

1. **Market Research**: Start by identifying trends and market data about the sustainable shoe industry. Look for information on the size of the market, its expected growth, key industry players, and the latest innovations in the field. Analyse consumer needs through surveys or interviews that can increase understanding of the type of product or service needed to satisfy that demand.
2. **Identifying the target market**: Determine which segment of consumers would be interested in purchasing sustainable shoes. Consider the demographic factors, purchasing behaviours and preferences of consumers who may be attracted to sustainable products.
3. **Engage consumers**: Interacting with customers through social media, focus groups or sending questionnaires can help gather direct feedback. Ask them what features they look for in sustainable shoes and what problems they want to solve.

4. **Competitor analysis**: Study the types of competitors in the sustainable shoes sector. Evaluate their product offerings, market positioning, marketing strategies, and customer reviews. This will help you better understand consumer needs.
5. **Supplier analysis**: Research suppliers of sustainable materials for shoe production. Evaluate their reputation, quality of materials, delivery times and prices.
6. **Price study**: Analyse the prices of sustainable shoes, considering production costs, profit margins and consumers' perception of value. Also evaluate the pricing strategies of the various competitors in the same commercial sector (e.g. sneakers made with recycled material)
7. **Distribution channel research**: Identify key distribution channels for sustainable shoes. Analyse the sales hypothesis through online store; physical point of sale, partnerships with other brands that share the same values.
8. **Marketing analysis**: Analyse the marketing strategy that various brands use to promote their sustainable product. Check out how various sustainable shoe brands use social media, influencers, traditional advertising, and collaborations to increase brand awareness and generate interest.
9. **Monitor consumer behaviour**: Analyse the type of feedback that existing customers give to the reference brands. This feedback helps to further improve the product and meet consumer needs.
10. **Sustainability assessment**: Check how many and which sustainable shoe brands have a traced and transparent supply chain. Consider case study use of recycled or biodegradable materials, energy efficiency, and environmentally friendly company policies.
11. **Continuous Monitoring**: Constantly monitor the market and keep the analysis updated on the latest trends and innovations in the industry.

What’s behind the intentions?

How to respond to what comes before the intention? After all, you don't wake up with an intention, you wake up with a need.

This is very clear when people talk: “I need something,” “I want something.”

And it's equally clear when they search online, too. In fact, this type of conversational language is increasingly used in search queries.

Searching, of course, is a powerful tool for both buyers and marketers. When it comes to doing a search, people literally type their needs into a form, which, in turn, generates data that marketers turn into insights.

But what ultimately drives search behaviour?

This is where the research conducted by Google together with Need Scope by Kantar (world leader in market research and marketing consultancy) comes in to better understand the motivations that drive search behaviours.

It is a qualitative and quantitative segmentation approach that uncovers the functional, social, and emotional drivers of consumer behaviour within a given market.

There are six basic needs identified by the research which correspond to six different search behaviours:

- Surprise me
- Thrill me
- Impress me
- Educate me
- Reassure me
- Help me

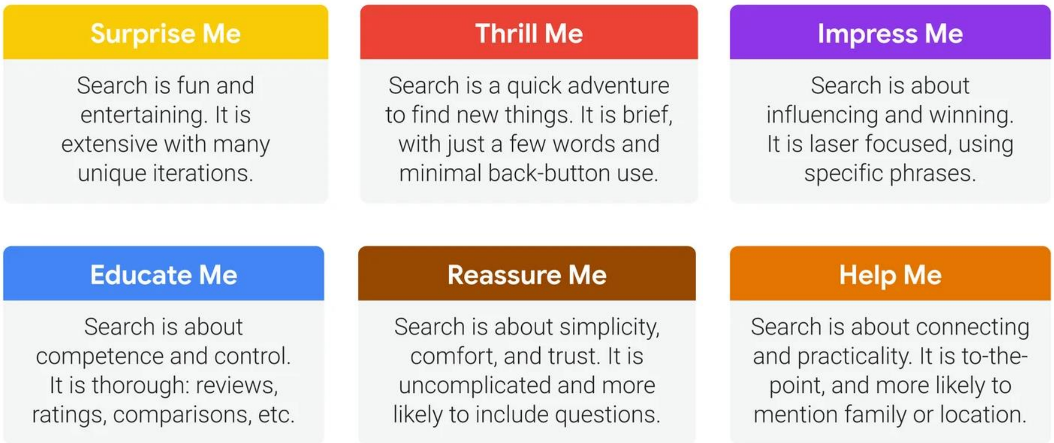


Figure 6. *How consumer needs shape search behavior and drive intent. Source: https://www.thinkwithgoogle.com/marketing-strategies/search/consumer-needs-and-behavior/*

5.3. THE CUSTOMER PERSONA

A customer persona, also known as a *buyer persona*, is a detailed and semi-fictional representation of an ideal customer based on market research, data analysis, and insights from existing customers. Creating customer personas helps businesses better understand and empathize with their target audience, allowing them to tailor their products, services, and marketing strategies to meet the specific needs and preferences of their customers.

A customer persona typically includes demographic information such as age, gender, occupation, and location, as well as psychographic details like interests, values, and behaviour patterns. Businesses may also include information about the challenges and goals of their ideal customers, enabling them to address specific pain points and provide solutions that resonate with their audience.

Developing customer personas is a valuable exercise for businesses because it enables them to:

- Target Marketing: By understanding the preferences and behaviours of their target audience, businesses can create more targeted and effective marketing campaigns.
- Product Development: Customer personas help in shaping products or services that cater to the specific needs and desires of the target market.

- Communication: Crafting messages and content that resonate with the target audience becomes easier when businesses have a clear understanding of their customer personas.
- User Experience: When designing websites, apps, or other customer interactions, businesses can consider the preferences and behaviours of their personas to enhance the overall user experience.

Customer personas serve as a valuable tool in developing a customer-centric approach, allowing businesses to build stronger connections with their audience and improve the effectiveness of their marketing efforts.

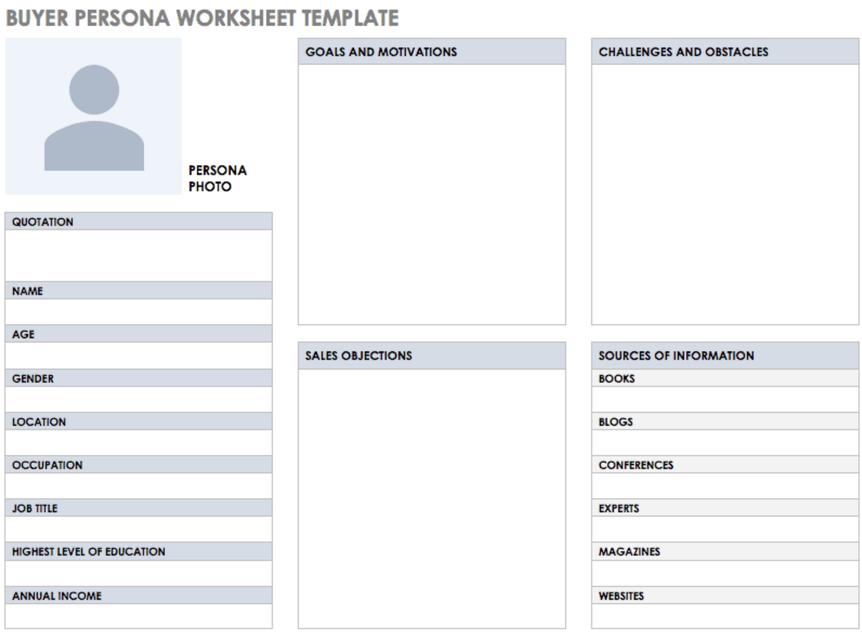


Figure 7. *How consumer needs shape search behavior and drive intent. Justin De Graaf, May 2019. Source: https://www.thinkwithgoogle.com/marketing-strategies/search/consumer-needs-and-behavior/*

LECTURE 6

FOLLOW THE FOOTWEAR FASHION AND MARKET TRENDS (IN RELATION TO SUSTAINABILITY AND CIRCULAR ECONOMY, ECO-FRIENDLY PRODUCTS…)

6.1. INTRODUCTION

In the world of fashion, a profound shift is underway—one that transcends aesthetics and immerses itself in ethical and environmental consciousness. This shift is exemplified by the emergence of sustainable footwear, a movement challenging traditional norm, urging us to revaluate our choices and the impact of our fashion footprint.

Sustainable footwear is not a fleeting trend but a commitment to responsible consumption. From design inception to the eventual disposal, sustainability is woven into every aspect, prompting a reconsideration of our relationship with the products we wear.

Sustainable footwear redefines material choices by embracing recycled fabrics—breathing new life into discarded plastics, rubber, and textiles. The narrative extends to the use of natural and organic materials, where bamboo and organic cotton take centre stage in this eco-friendly saga.

More than a product, sustainable footwear places a spotlight on the people behind it. Ethical manufacturing becomes more than a buzzword; it's a commitment to fair labour practices. Each pair of shoes becomes a testament to humane conditions and fair wages, challenging the notion that fashion should come at the cost of human well-being.

In a society driven by fast fashion, sustainable footwear champions a circular economy. Rejecting disposability, it encourages designs that withstand the test of time. Recycling and upcycling become integral elements in crafting a closed-loop system, where the end is not an endpoint but a new beginning.

Nowadays information is power, and transparency becomes a virtue. Brands committed to sustainable footwear reveal the intricacies of their supply chains, fostering trust and inviting consumers to actively participate in the sustainability narrative.

Sustainable fashion is a dialogue between brands and consumers. Education and awareness campaigns empower individuals to understand the impact of their choices. Informed consumers become catalysts for change, steering the industry towards a more sustainable course.

Certifications stand as beacons in the labyrinth of sustainable fashion, offering assurance that a brand doesn't just speak of sustainability but lives and breathes it through adherence to industry standards.

Collaborations between sustainable footwear brands and designers are crucibles of innovation. Style merges seamlessly with ground-breaking materials and designs, pushing the boundaries of what sustainable fashion can achieve.

Sustainable fashion extends beyond new purchases. The resurgence of second-hand and vintage footwear signifies a shift in consumer mindset—a realisation that every step can be a stride towards a circular economy, where the life of existing products is extended.

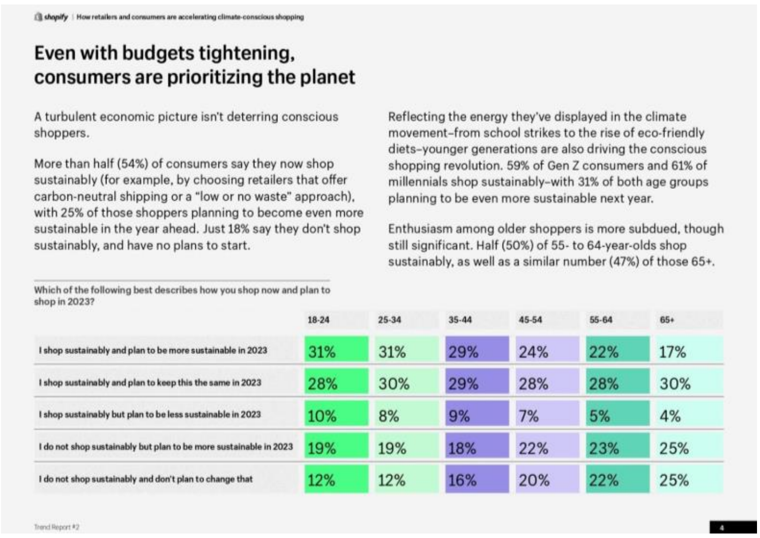
Sustainable footwear is not a solo act; it's a symphony. Industry-wide initiatives and policies advocate for sustainable practices, creating an ecosystem where brands are stewards of a collective responsibility.

6.2. THE FOOTWEAR SECTOR AND THE SUSTAINABLE APPROACH

A comprehensive study

“Climate change awareness is now prevalent in the purchasing choices of consumers around the world”. In fact, **62% of them** are not willing to compromise in terms of sustainability, even during this period of economic uncertainty. This was stated by Shopify, which conducted an online survey in this regard together with Sapio Research.

The research resulted in the “Conscious Commerce” report, which reveals how consumers and companies are continuing to engage in sustainable practices, encouraging solutions such as zero-carbon shipping and paying attention to climate-friendly practices, despite the crisis dictated by an increase in the cost of living and a reduction in the spending budget.


shopify | How retailers and consumers are accelerating climate-conscious shopping

Even with budgets tightening, consumers are prioritizing the planet

A turbulent economic picture isn't deterring conscious shoppers.

More than half (54%) of consumers say they now shop sustainably (for example, by choosing retailers that offer carbon-neutral shipping or a “low or no waste” approach), with 25% of those shoppers planning to become even more sustainable in the year ahead. Just 18% say they don't shop sustainably, and have no plans to start.

Reflecting the energy they've displayed in the climate movement–from school strikes to the rise of eco-friendly diets–younger generations are also driving the conscious shopping revolution. 59% of Gen Z consumers and 61% of millennials shop sustainably–with 31% of both age groups planning to be even more sustainable next year.

Enthusiasm among older shoppers is more subdued, though still significant. Half (50%) of 55- to 64-year-olds shop sustainably, as well as a similar number (47%) of those 65+.

Which of the following best describes how you shop now and plan to shop in 2023?

	18-24	25-34	35-44	45-54	55-64	65+
I shop sustainably and plan to be more sustainable in 2023	31%	31%	29%	24%	22%	17%
I shop sustainably and plan to keep this the same in 2023	28%	30%	29%	28%	28%	30%
I shop sustainably but plan to be less sustainable in 2023	10%	8%	9%	7%	5%	4%
I do not shop sustainably but plan to be more sustainable in 2023	19%	19%	18%	22%	23%	25%
I do not shop sustainably and don't plan to change that	12%	12%	16%	20%	22%	25%

Trend Report #2 4

Figure 8. *How retailers and consumers are accelerating climate-conscious shopping.*
Source: https://www.shopify.com/plus/commerce-trends

82% of the merchants interviewed globally also declared how, in their opinion, there is a strong correlation between sustainability and the improvement of business performance itself, or how sustainable practices are now essential for business success.
Stacy Kauk, Head of Sustainability at Shopify, says: “This report demonstrates that climate awareness is driving consumer purchasing decisions, even in difficult economic circumstances. It is therefore in everyone's interest to implement sustainable practices, such as adopting a "low or no waste" approach to producing and offering zero-emission shipping. We hope that more and more companies will join us in developing innovative carbon removal technologies, which It's part of our goal to turn the tide on climate change."

Consumers do not give up on sustainability despite the high cost of living.
Globally, many consumers put green practices first and 54% already make sustainable purchases, for example choosing retailers that offer zero-emission shipping.
The report highlights how consumers around the world are actively changing their purchasing habits, making choices that have a positive impact on the planet such as eliminating unnecessary purchases (35%), choosing products with recyclable or eco-friendly packaging (24%) and shopping locally (24%). This is a constantly increasing trend, even if 38% of consumers declared themselves cautious in spending (45% in Italy) due to the increase in the cost of living.
Europe is also first place in the world in terms of conscious purchasing: looking at Italy, it emerged that 64% of Italian consumers shop sustainably and plan to continue to do so, while 37% of those interviewed are willing to spend even more to buy from a sustainable brand – especially Millennials (46%) and Gen Z (38%).

And it is in fact the younger generations who are leading the conscious shopping revolution, driven by the urgency of climate change: 59% of Gen Z and 61% of Millennials globally already make sustainable purchases, while 31% of both age groups wants to be even more sustainable this year.
Cost is the main obstacle to sustainability for businesses. Some companies reveal that cost is the main barrier to greater sustainability, with particular reference to larger companies, which may have more complex supply chain constraints. And in fact, if 40% of companies with 1-50 employees indicate it as a real obstacle, the percentage grows to 48% for larger companies (501-1,000 employees).
While costs can be an obstacle, especially during this time, larger retailers are the most likely (46%) to view the current economic landscape as an opportunity to accelerate their sustainability programs. In the future, in fact, those who are more attentive to the climate will not only receive greater interest from consumers but will also represent an economic advantage for the companies themselves. “

The sustainability process in the footwear industry

The role of sustainability in the footwear sector, examining its evolution within the complex production chain, is related to economic, social and production dynamics and can be summarized in 'conscious consumption, transparency in relationships between producing companies/suppliers/end consumers, research and promotion of new portions of the market adhering to the sustainable lifestyle', the challenge of the footwear industry, in this sense, is to be able to intercept these trends and convert them into new approaches and sustainable business models. Without a doubt, footwear production employs a very complex and diversified supply chain, in which it is often difficult to trace sustainability parameters that can be uniformly adapted to the entire sector, but nevertheless in it is possible to trace some essential elements that delimit the scope of reflection, filtering production processes under the lens of environmental sustainability items.

The question of the non-sustainability of many production realities is being talked about more and more often, sometimes under the pressure of serious news events and campaigns with great media impact, but also above all thanks to the greater sensitivity of consumers who are increasingly questioning themselves about the history of product they are purchasing and the cost to the environment of its production. In fact, the conviction has developed that only from new business models and shared projects that intervene on the degree of sustainability of raw materials, accessories, logistics, production and distribution processes, packaging, up to the post-consumption life of the product, a more sustainable fashion can be born. The push for change towards sustainability within the fashion system in general and the footwear industry in particular also arose, on the one hand, from the regulations protecting the environment and workplace safety which over time have been issued at a national and international level, and on the other hand, by the pressures of local communities, especially in those districts where the concentration of companies in the sector has highlighted the need to intervene on pollution phenomena.

The topic of recycling and reuse is, as is known, one of the key issues when discussing sustainability. Being a sustainable company increasingly means not only respect for the environment, but also respect for the health of workers and consumers, saving of raw materials and economic resources, respect for human rights, rationalization of creative and production processes, reduction of waste, creation of new and more transparent links with communities of interest and exploration of new fair trade market areas.

The role of green communication and marketing, analysing on the one hand how companies communicate the values of sustainability and on the other the crucial role played by e-commerce in the success of those companies most devoted to sustainability, which thanks to the web are able to be easily intercepted by consumers who are increasingly aware and attentive to the purchase and consumption of products that produce an increasingly lower impact on the environment and a respectful use of resources.

The "sustainable" link between producers, suppliers and consumers is the central element on which fashion companies, and in our case footwear, must focus their attention more.

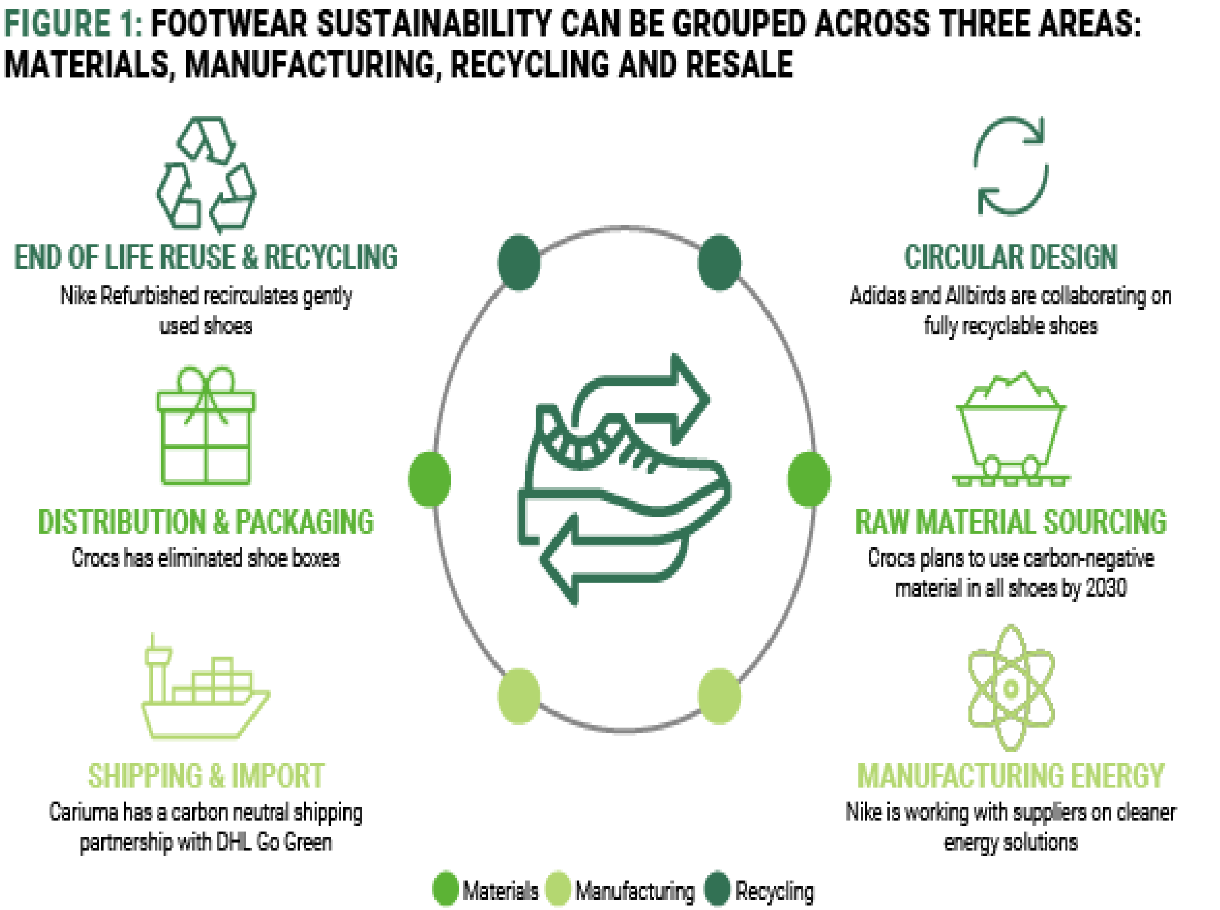


Figure 9. Footwear sustainability can be grouped across three areas: materials, manufacturing, recycling and resale. Source : https://www.alixpartners.com/insights-impact/insights/retail-viewpoint-footwears-bigger-sustainability-challenges-mean-the-time-to-act-is-now/

Through their behaviour, consumers are aware that they are contributing to "building" the supply of those goods and services for which they demand on the market. In this sense, the value of the good increasingly depends on the consumer and his perception, on his willingness to purchase and on the amount of information he can put forward to appreciate its consumption, having as a reference horizon the entire production chain of what he buys.

In the general framework of a new circular economy, interest in sustainable shoes is constantly growing, both in Italy and in Europe. As people become more committed to sustainability and environmental awareness, more and more consumers are interested in products that have minimal impact on the environment.

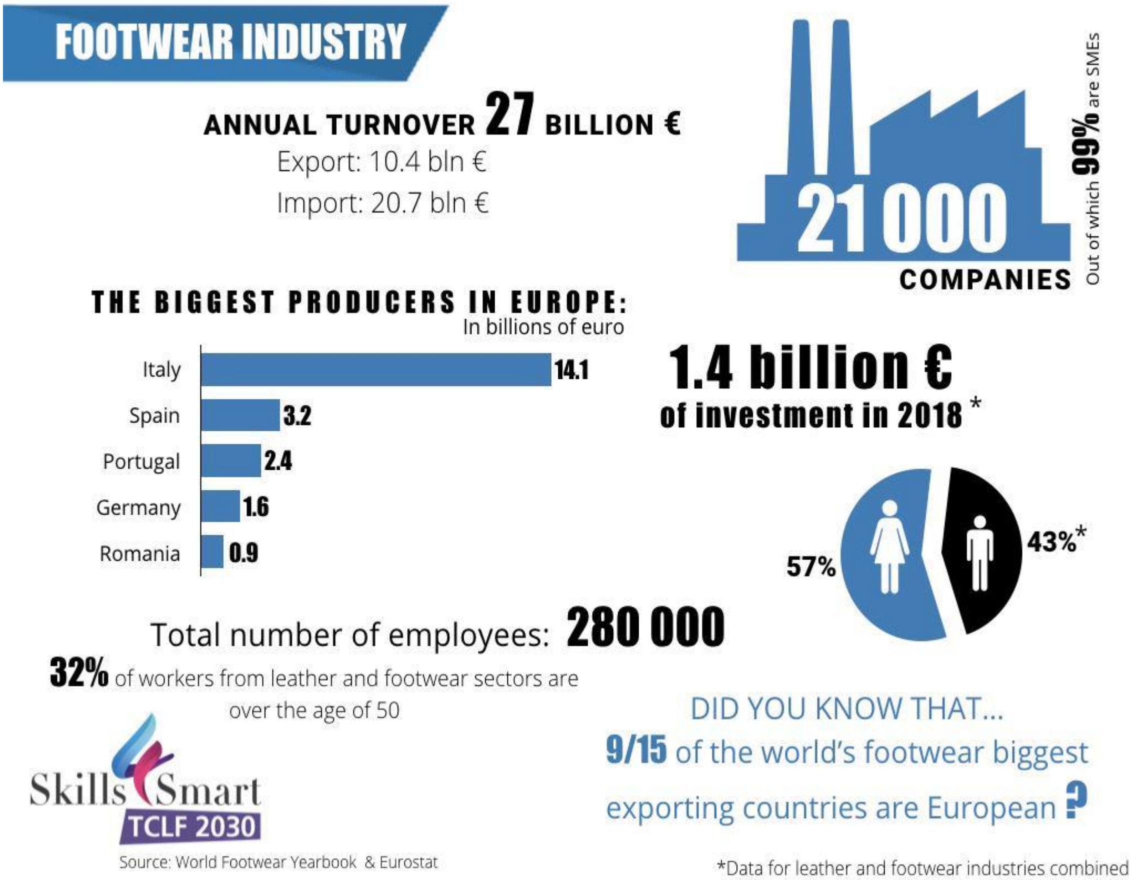


Figure 10. *Footwear industry budget.*
Source: https://s4tclfblueprint.eu/project/tclf-sectors/european-footwear-industry/

As for Europe, the sustainable shoe industry has seen significant growth in recent years. According to Modor Intelligence research done in 2021, the European sustainable shoe market is expected to experience compound annual growth of 7.6% from 2021 to 2026. This indicates an ever-increasing interest from European consumers in sustainable shoes. However, keeping in mind that the sustainable shoe market is still relatively new, sales percentages may vary depending on several factors such as consumer awareness, accessibility of sustainable products, and availability of sustainable brands on the market.

How to be more sustainable…

To follow footwear fashion and market trends in relation to sustainability, the circular economy and eco-sustainable products, we can consider the following approaches:

1. **Research and analysis of market trends**: Keep up to date on the latest trends in the footwear sector, focusing in particular on the issues of sustainability, circular economy and eco-sustainable products. Read specialized magazines, participate in trade fairs and follow influencers or experts in the field.
2. **Partnering with Sustainability Experts**: Connecting with sustainability industry experts can help you better understand the challenges and opportunities associated with creating eco-friendly products. This collaboration can help you identify sustainable materials, manufacturing processes and business practices.
3. **Attending Conferences and Workshops**: Attending conferences and workshops focused on sustainable and circular fashion gives you the opportunity to learn, connect with other people in the industry, and stay up to date on the latest innovations and trends in the field.
2. **Direct observation and competitor analysis**: Monitoring what the main shoe brands are doing in the field of sustainability and the circular economy can provide useful insights. Analyze the materials they use, the sustainable production practices they adopt and their communication strategies in promoting eco-sustainable products.
3. **Networking**: Build a network of contacts within the sustainable fashion and footwear industry. Attend events, meet other professionals, participate in online groups or associations that deal with sustainability and circular economy in the fashion sector. These connections can help you stay up to date on trends and exchange ideas with people who have similar interests.

6.3. MARKET TRENDS RELATING TO SUSTAINABLE SHOES

1. **Eco-sustainable materials**: More and more brands are using recycled, organic, and biodegradable materials to produce their shoes. These materials include recycled plastic, recycled rubber, organic hemp, organic cotton, cork, and plant-based fabrics.
2. **Ethical Manufacturing**: The public is demanding transparency and accountability from shoe brands. This means companies are adopting ethical and sustainable manufacturing practices, such as ensuring fair wages and safe working conditions for their employees.
2. **Product life cycle care**: Many brands are promoting the durability and repairability of shoes. This translates into offering long-term warranties, repair programs, replacements for damaged parts and promoting the culture of reuse, rather than simply throwing them away.
3. **Design and style**: Sustainable shoes are becoming increasingly trendy and fashionable. One of the ways brands have made sustainability "cool" is through collaborating with high-profile fashion designers and influencers, creating accessible, yet attractive shoes.

4. **Technological innovations**: Some companies are experimenting with new technologies to create sustainable shoes. These innovations include 3D printing, using lightweight aerospace materials, integrating solar panels to charge electronic devices embedded in shoes, and much more.
5. It is important to note that these trends are developing and changing rapidly, depending on consumer needs and preferences. Therefore, it is advisable to keep up to date on the latest news in the sustainable shoe sector by consulting sector websites, fashion blogs and the social pages of the main reference brands.

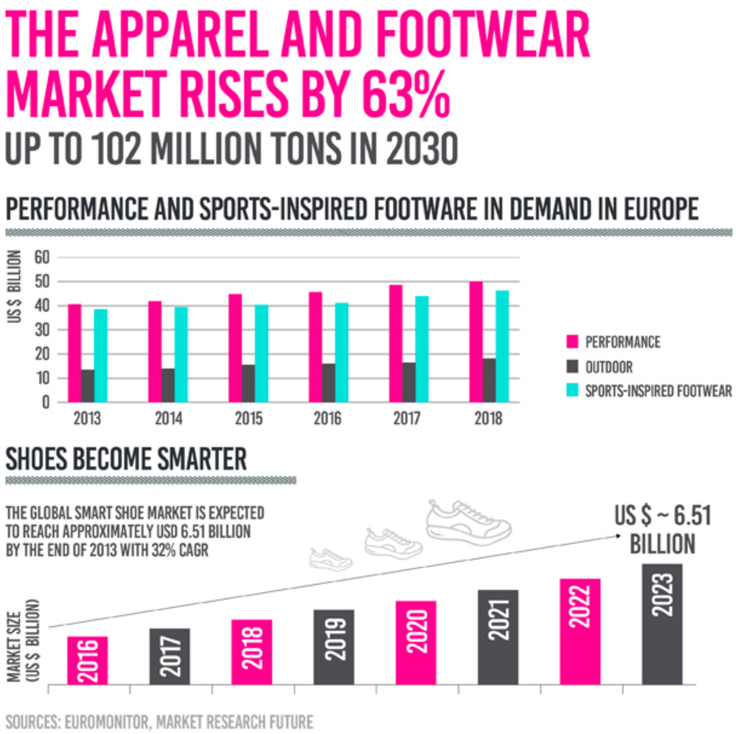


Figure 12. *Performance and sport inspired footwear are in demand in Europe. Source : https://www.focusingfuture.com/me-consumer/future-of-shoes-smart-athleisure-sustainable/*

What drives the growth of the sustainable footwear market?

The majority of demand for footwear soles will come from the sports and fashion industries in all geographic areas. Despite a decline in 2020 due to the impact of the pandemic, the manufacturing industry is currently in full recovery.

Growing awareness about health and fitness and the consequent increase in sporting activities is driving a growing demand for specific footwear across all geographies. The growing popularity of sporting events also has a positive influence on the growth of the market.

The market is also driven by the increase in the number of women practicing outdoor activities. Furthermore, the increasing number of working women is expected to further push the growth of the market.

The demand for customized footwear, especially for therapeutic purposes, will create substantial growth prospects for market players across all regions. Increasing demand for medical footwear across the globe for patients suffering from chronic diseases such as arthritis, diabetes, and knee problems will accelerate the market growth.
The growing demand for comfortable shoes in line with fashion trends, especially among the young population, will be one of the main market trends. Changing footwear purchasing preferences based on the occasion is another major market trend. Sports and casual footwear are some of the types that are getting great demand.
Based on the type of sole material, the leather segment still represents the largest market share (approximately 58% by value), followed by plastic and rubber respectively.

Recovery of footwear rubber

Growing consumer awareness is reflected in manufacturers' increased attention to using recycled materials. There are several manufacturers of sports footwear, such as Puma, Nike, Golden Goose or ACBC, who have made sustainability a rule of design and development of new models.
Like the recycling of used tyres, the recycling of the rubber soles of sports shoes also represents a useful solution for reducing waste and the consumption of virgin raw materials.
Rubber Conversion has an ongoing research program, together with one of the main global brands of sports footwear, for the reuse of rubber both by recovering that of the soles at the end of its life and by installing systems for the recovery of scraps and production waste directly on the sites productive.

The process patented by Rubber Conversion allows the rubber to be devulcanized, obtaining a secondary raw material that can be reused in new compounds with percentages of up to 30%, guaranteeing significant savings in terms of costs, but also great advantages in terms of environmental sustainability.

LECTURE 7
DIGITAL MARKETING/PROMOTION OF PRODUCTS THROUGH NEW ICTS AND SOCIAL MEDIA

7.1. INTRODUCTION

In the ever-evolving landscape of commerce, the synergy between cutting-edge Information and Communication Technologies (ICTs) and the pervasive reach of social media has significantly reshaped the paradigms of product promotion. The amalgamation of these technological advancements has revolutionized the way businesses connect with their audiences, presenting an unparalleled opportunity for strategic marketing initiatives.

The integration of emerging ICTs offers an array of tools and platforms that empower businesses to engage with their target demographics on a global scale. Simultaneously, the proliferation of social media channels has redefined the means through which products and services are marketed and consumed. This digital metamorphosis has transformed traditional marketing methodologies into a dynamic, interactive, and customer-centric landscape.

Harnessing these advancements effectively necessitates an in-depth understanding of the technological nuances and an astute comprehension of audience behaviors within the realm of social media. By leveraging these innovations, businesses can establish a robust digital presence, tailor compelling marketing campaigns, and foster meaningful connections with their customer base.

The evolution of digital marketing through new ICTs and social media presents an exciting frontier for businesses seeking to enhance their promotional strategies and maximize their outreach in an increasingly digital world. Understanding and capitalizing on these technological tools have become imperative for businesses striving to remain competitive and relevant in today's market.

Figure 13. *The digital Marketing.*
Source: https://www.shutterstock.com/it/image-vector/digital-online-marketing-banner-web-icon-1210134190

7.2. DIGITAL MARKETING

What Digital Marketing is

Digital marketing refers to the practice of promoting and selling products or services using online marketing tactics and channels, leveraging the internet, electronic devices, and various digital technologies. It encompasses a broad spectrum of activities that enable businesses to connect with customers where they spend much of their time: online. It differs from traditional marketing in that it uses channels and methods that enable and organization to analyse marketing campaigns and understand what is working and what isn't almost in real time.

Factor	Traditional	Digital
Reach	Limited to Area	Global
Targeting	Not Specific	Very Specific
Price	Very Expensive	Not Expensive
ROI	Not Guaranteed	Guaranteed

Figure 14. *Traditional Marketing vs. Digital Market*

Digital Marketing objectives serve to establish a strong online presence, drive meaningful engagement, and contribute to the growth and success of a business in the digital realm. Namely, main Digital Marketing objectives are:

- **Increasing Brand Awareness**, creating and enhancing the visibility and recognition of a brand among its target audience through various online channels and strategies.
- **Generating Leads and Sales**, driving potential customers to take action, such as making a purchase, subscribing, or filling out a form, thus converting leads into sales.
- **Building Customer Relationships**, fostering and nurturing relationships with current and potential customers by engaging and providing value through content and interactions.
- **Boosting Website Traffic**, increasing the number of visitors to a website through various tactics, including search engine optimization, social media marketing, and compelling content.
- **Improving Customer Engagement**, encouraging active participation, interaction, and communication between the brand and its audience, leading to higher engagement rates.
- **Enhancing Customer Loyalty**, retaining existing customers by delivering exceptional experiences, providing valuable content, and maintaining ongoing communication.
- **Measuring and Analysing Performance**, using data and analytics to measure the effectiveness of marketing strategies and campaigns, thereby allowing for continuous improvement.
- **Adapting to Changing Trends**, staying up-to-date with the latest trends and technologies in the digital space to remain relevant and competitive.

Figure 15. *Digital Marketing.*
Source: https://www.linkedin.com/pulse/digital-marketing-abbreviations-short-forms-streak-marketing/

Digital Market key aspects

In the digital marketing landscape, success hinges upon four pivotal pillars: Data-Driven Decisions, Targeted Approach, Personalization, and Continuous Optimization.

Data-Driven Decisions:

Digital marketing heavily relies on data and analytics to make informed decisions. This involves the collection, analysis, and interpretation of data obtained from various sources such as website traffic, social media metrics, email interactions, customer behavior, and more. By assessing this data, marketers can gain valuable insights into customer preferences, behaviors, and the effectiveness of marketing campaigns. This enables them to adjust strategies, allocate resources more effectively, and make decisions based on evidence rather than assumptions, improving overall performance and return on investment (ROI).

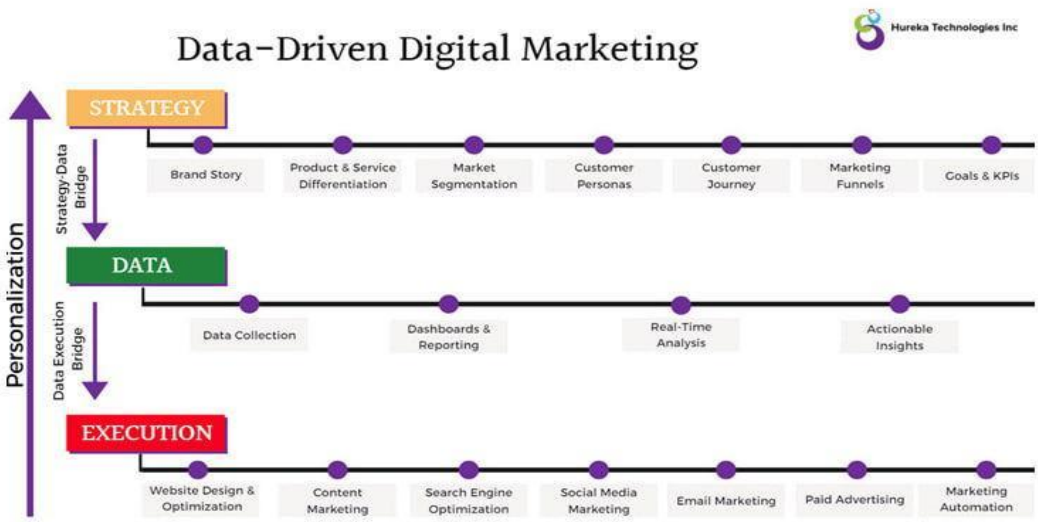


Figure 16. *How to set up data driven marketing for your online brand.*
Credit: HUREKA TECHNOLOGIES INC. Partnering with Mission-Driven Entrepreneurs.

Targeted Approach:

A targeted approach involves directing marketing efforts toward specific demographics or niches rather than adopting a broad, one-size-fits-all strategy. By identifying and understanding the characteristics and behaviours of a specific audience, marketers can tailor their messages, content, and advertising to resonate more effectively with a particular group. This focused approach increases the likelihood of reaching individuals who are more likely to engage with the brand or convert, thus improving conversion rates and maximizing the impact of marketing efforts.

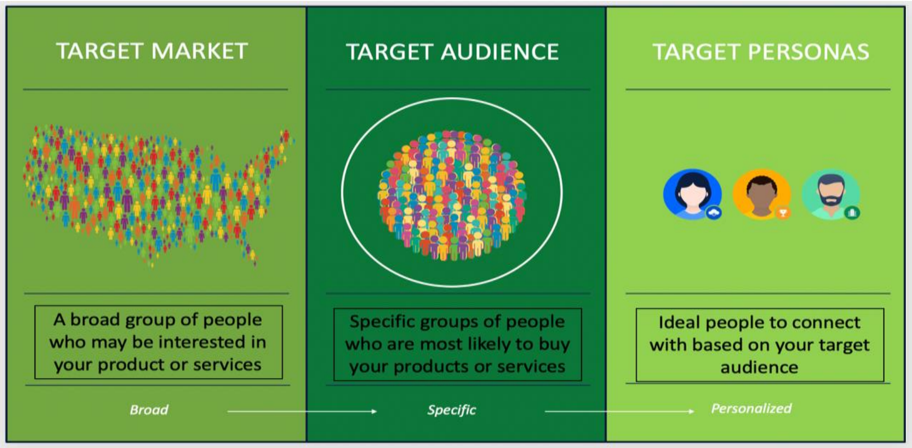


Figure 17. *Targeted approach. Credit: LinkedIn*

Personalization:

Personalization in digital marketing involves creating customized and individualized experiences for consumers based on their preferences, behaviours, and past interactions with the brand. It includes delivering tailored content, product recommendations, and communications that align with the specific needs and interests of each customer. Personalization enhances the customer experience, strengthens brand loyalty, and increases the likelihood of conversions. Utilizing data and automation tools, marketers can create highly personalized campaigns that resonate with their audience on a deeper level.

Continuous Optimization:

The digital landscape is dynamic and constantly evolving. Continuous optimization involves the ongoing process of testing, analyzing, and refining marketing strategies to enhance performance and effectiveness. This can include A/B testing, refining content based on audience responses, adjusting ad campaigns for better conversion rates, and optimizing website user experience. By constantly iterating and improving strategies, marketers can adapt to changing trends, refine their approaches for better results, and stay ahead in a highly competitive online environment.

Digital Market components

Digital marketing comprises several essential components that collectively form a comprehensive strategy for businesses to thrive in the online landscape. Establishing a strong online presence through websites and social media platforms is fundamental, followed by content creation and distribution to captivate and engage the target audience. Search Engine Optimization (SEO) and Search Engine Marketing (SEM) work hand-in-hand to boost a brand's visibility in search results, with SEO focusing on organic traffic and SEM on paid advertising. Social Media Marketing harnesses the power of various platforms to connect with audiences, while email marketing delivers tailored messages to specific groups. The data-driven aspect, fueled by analytics, empowers marketers to assess, refine, and optimize strategies, ensuring maximum impact and return on investment.

Online Presence:

This involves creating a strong digital footprint for a brand or business. It encompasses having a well-designed and functional website that represents the brand's identity, values, and offerings. It's not limited to just a website; it extends to various online platforms, including social media, online directories, and e-commerce sites, ensuring a consistent and professional representation across all these channels.

Content Creation and Distribution:

Content is the heart of digital marketing. It involves creating diverse and engaging content such as blog posts, videos, infographics, podcasts, and more. The key is to produce valuable, informative, and entertaining content that resonates with the target audience. Distribution involves sharing this content across relevant platforms to reach and engage the audience.

Figure 18. *Content creation. Source: https://as1.ftcdn.net/v2/jpg/04/87/77/88/1000_F_487778800_nlFsNgpDYhzOgRwI6K5ZAyN7PBvLlfyK.jpg*

Search Engine Optimization (SEO):

SEO is the practice of optimizing a website to improve its visibility and ranking in search engine results. This involves various strategies like keyword research, on-page optimization, link building, and creating high-quality, relevant content that search engines consider valuable for users.

***Figure 19. SEO**. Source : https://pixabay.com/illustrations/seo-analysis-online-3693149/*

Search Engine Marketing (SEM):

Unlike SEO, SEM involves paid strategies to increase a website's visibility in search engine results pages (SERPs). This is typically done through paid advertising, like Google Ads, where advertisers bid on keywords to display their ads in search results.

Social Media Marketing:

Utilizing social media platforms (such as Facebook, Instagram, Twitter, LinkedIn) to engage with audiences, build brand awareness, and drive traffic. This involves creating and sharing content, interacting with followers, running ads, and utilizing analytics to understand audience behaviour.

Email Marketing:

Sending targeted, personalized messages to a specific audience through email. This can include newsletters, promotional content, follow-ups, and personalized recommendations. It's a highly effective way to nurture leads, retain customers, and drive sales.

Data Analysis:

Data-driven decisions are crucial in digital marketing. Analyzing various metrics and data points helps marketers understand the effectiveness of their strategies. This includes tracking website traffic, engagement metrics, conversion rates, and other key performance indicators (KPIs). By using analytics tools, marketers can optimize campaigns for better performance.

7.3. SOCIAL MEDIA MARKETING

People are increasingly connected online, dedicating much of their time to social networks. These places have become not only platforms for socialization and entertainment, but real reservoirs of information.
Social Media Marketing (**SMM**) has become a valuable tool for driving sales, acquiring customers, and building brand loyalty. Companies, professionals, and public figures are increasingly adopting SMM to achieve their goals.
However, not everyone approaches this discipline with the right awareness. Creativity alone is not enough; in-depth analysis and skills acquired through study and continuous experience are required.

SMM uses social networks to connect brands with potential customers, taking on a central role in communication strategies over time. The advantages are obvious: relatively low costs and an easily measurable return. Businesses can promote brands, improve reputations, increase customer loyalty, manage relationships, drive sales and more.
Platforms like Instagram offer virtual spaces for selling, and user reviews are valuable tools. Before including a platform in a marketing strategy, strategic planning that considers the characteristics of the company and the target audience is essential.
Presence on social media cannot be casual; it must be well planned, considering internal factors (values, objectives) and external factors (competitors' strategies, target behaviour). The key is to understand how the SMM can enhance the brand, balancing budget, and resources.

Figure 20. *Main social media channels.*
Source : https://pixabay.com/vectors/icon-set-social-media-contact-web-1142000/

Clear definition of the audience, specific objectives and the choice of social channels are crucial. The social media content strategy requires an editorial plan and an editorial calendar that guide the publication of content.

The choice of content types (images, texts, videos) depends on the platform used. The tone of voice must be suitable for the social network and the recipient of the message. Periodic monitoring of results through KPIs is essential to evaluate the effectiveness of the strategy.

The selection of platforms in the social media mix requires careful study, considering the characteristics and audience of each. Audience profiling is essential, taking into account factors such as age, gender and purchasing habits.

Cost estimation is also crucial to avoid waste. Advertising on social media offers opportunities for return on investment, thanks to user profiling. The ability to measure results immediately allows for timely modification of the strategy.
Social Media Analytics provides detailed information on users, allowing you to understand behaviours and results. Platforms such as Instagram Insight and Facebook Insight offer internal tools to analyse data from Social Media Marketing activities.

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MODULE 6
WASTE MANAGEMENT STRATEGIES - BEST PRACTICES IN FOOTWEAR SECTOR

BY **AGNI VYTANIOTI**
CREATIVE THINKING DEVELOPMENT

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

LECTURE 1
WASTE MANAGEMENT IN A CIRCULAR ECONOMY

1.1 INTRODUCTION

Circular economy refers to an economic system designed to maximize resource efficiency and minimize waste generation by closing the loop of product lifecycles. In a circular economy, the traditional linear model of "take-make-dispose" is replaced with a regenerative approach that focuses on reducing, reusing, recycling, and recovering materials and products.

The concept is based on the idea that resources are limited, and the traditional linear model of production and consumption is unsustainable in the long run. In a circular economy, products and materials are kept in use for as long as possible, and their value is maintained through multiple cycles of use and reuse.

Figure 1. *Environment and Circular Economy*

A circular economy entails markets that give incentives to reusing products, rather than scrapping them and then extracting new resources. In such an economy, all forms of waste, such as clothes, scrap metal and obsolete electronics, are returned to the economy or used more efficiently.

This can provide a way to not only protect the environment, but use natural resources more wisely, develop new sectors, create jobs and develop new capabilities.

1.2 THE GREAT FIVE R 'S OF CIRCULAR ECONOMY

A circular economy, which is often called one of the best possible solutions to our problems, consists of 5 consumerism-altering concepts – Reducing, Reusing, Refurbishing, Repairing and Recycling.

Figure 2. *Pete Seeger, American folk singer, and social activist.*

Instead of buying new goods rent or borrow an item.

Reduce

As a society, we have limited resources. So, why are we increasing our consumption if neither we as the consumers nor the Earth as a source benefit from that? That's why our choice should be clear – we must reduce our consumption. This can be achieved by sharing and renting.

Use a product over and over again to extract the maximum benefit from it, before breaking it down to its constituent parts and recycling it.

Reuse

A circular economy is based on designing items that have multiple ways of use by either changing their primary purpose or not. Reuse means the valuable materials we create keep their value across many lifetimes. Products designed for perfect performance, again and again, until recycling brings their value back into play once more. And repeat.

Repair and give products and goods a second life.

Repair

Items created while following the principles of circular economy are created from materials that can be easily repaired. It not only includes choosing high-quality materials but also designing the product in an easy-to-be-repaired way.

Refurbishing items can have a positive impact on both the environment and the economy.

Refurbish

Refurbishing includes fixing the original item by changing its old parts with new ones. One of the best examples of easy refurbishment is the German shoe brand Birkenstock. These sandals are designed so that all of their details can be easily disassembled by a shoemaker.

Used materials that would be considered waste can be transformed into new ones.

Recycle

The last R of circular economy is recycling. Only when certain items or materials cannot be used again due to them being worn out, the recycling of the old material can happen.

8. 2. KEY PRINCIPLES OF THE CIRCULAR ECONOMY

Circular economy is based in key principles that are part of a resilient system that is good for business, people, and the environment.

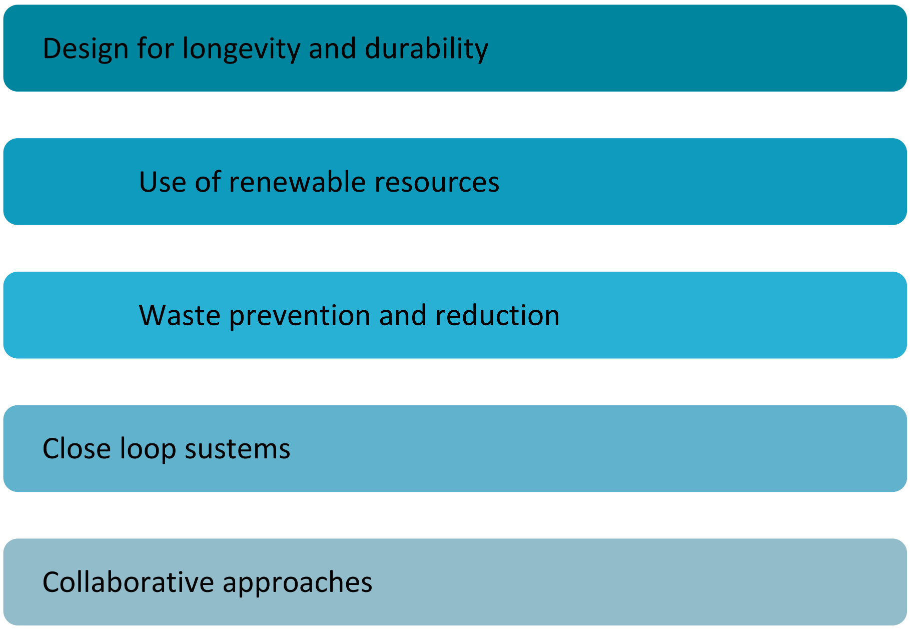


***Figure 3**. Key principles of the circular economy*

Design for longevity and durability:
Products are designed to be long-lasting, repairable, and upgradable, with a focus on quality and durability.

Use of renewable resources:
The emphasis is on utilizing renewable resources, such as solar and wind energy, to reduce dependence on finite resources.

Waste prevention and reduction:
Waste generation is minimized through strategies like waste prevention, recycling, and upcycling. Materials and components are recovered and reintroduced into the production process.

Closed-loop systems:
The aim is to create closed-loop systems where materials are continuously circulated and reused, either in their original form or as inputs for other products.

Collaborative approaches:
Collaboration between businesses, governments, and consumers is essential for the successful implementation of a circular economy. It involves sharing knowledge, resources, and expertise to optimize resource use and minimize waste.

The benefits of a circular economy include reducing environmental impact, conserving resources, creating new business opportunities, fostering innovation, and promoting sustainable economic growth. It aims to decouple economic growth from resource consumption and environmental degradation, ultimately creating a more sustainable and resilient future.

1.3 WASTE MANAGEMENT IN CIRCULAR ECONOMY

In a circular economy, waste refers to any material or substance that is discarded, disposed of, or no longer useful in its current form or state. The concept of waste is fundamentally different in a circular economy compared to a linear economy, where products are manufactured, used, and then disposed of as waste.
This Ellen MacArthur Foundation system diagram in figure 4, illustrates the continuous flow of technical and biological materials through a circular economy.

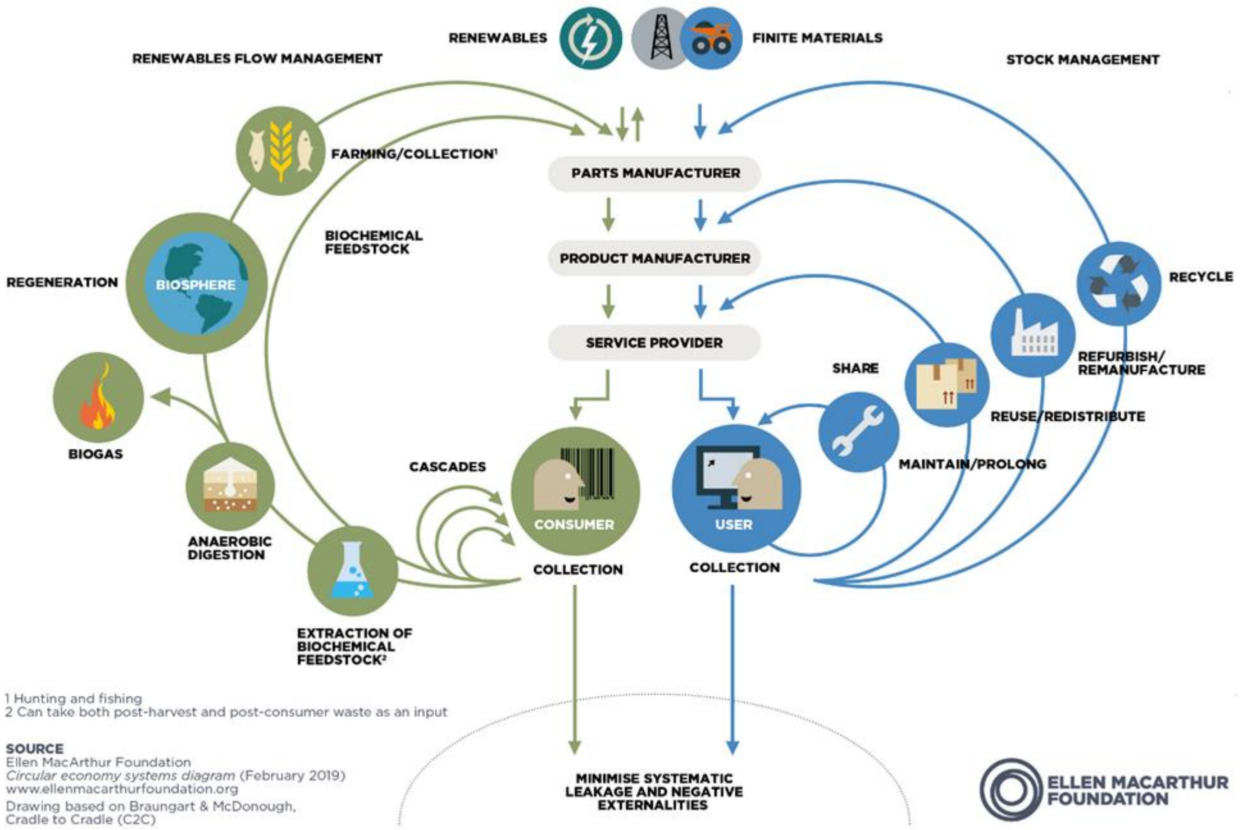


***Figure 4**. System diagram that illustrates the continuous flow of technical and biological materials through a circular economy. Source: Ellen MacArthur Foundation*

Why waste management is important?

Waste management could be defined as the processes and practices aimed at collecting, transporting and disposing of garbage, sewage and other waste products. The goal of waste management is to increase the product’s lifecycle and reuse and recover materials where possible, in order to reduce the total amount of waste that goes into landfill and minimize the environmental burden. The final goal pursued through this practice is thus to recreate a valuable resource through responsible disposal of rubbish, which is why waste management plays a crucial role in supporting sustainable development and the transition towards circular economy.

In a circular economy, the goal is to minimize waste generation by keeping materials and products in circulation for as long as possible through various strategies such as reuse, repair, remanufacturing, and recycling. Waste is seen as a potential resource that can be recovered, regenerated, or transformed into new products or materials, thereby closing the loop and reducing the need for extracting and processing virgin resources.

Benefits of waste management

With the deteriorating Earth state that we live in nowadays, waste management appears to be one of the most important environmental protection strategies. This practice has, in fact, several benefits both on the environment and the society. In particular, the main benefits of waste management are:

Environmental protection and pollution reduction. One of the primary benefits of waste management lies in its ability to minimize the environmental impact of human activities. Proper waste disposal and recycling reduce the amount of waste that ends up in landfills or incinerators, thereby decreasing greenhouse gas emissions and air pollution. By diverting waste from landfills, we conserve valuable space and reduce the risk of harmful substances leaking into the soil and contaminating water sources, protecting both human health and ecosystems.

Resource conservation. Waste management fosters resource conservation through recycling and reusing materials, reducing the total amount of material reaching final disposal. Recycling allows us to reclaim valuable resources from discarded items and, by doing so, we minimize the need for raw material extraction, thus conserving natural resources and mitigating the environmental impacts associated with the extraction and processing of raw materials.

Economic benefits. There are plenty of economic benefits deriving from waste management: not only this practice reduces the overall cost of waste disposal, but also fosters the creation of job opportunities. Last but not least, investing in waste management processes boosts companies' reputation, attracting customers and investors.

Enabling a circular economy. Waste management is a key enabler of the circular economy, a model aimed at reducing waste and optimizing resource use. In a circular economy, products and materials are designed for longevity, reuse, and recyclability. This transition from a linear "take-make-dispose" model to a circular one is fundamental in achieving a sustainable and greener future, and it is evident how waste management plays a big part in it.

1.4 TYPES OF WASTE IN CIRCULAR ECONOMY

Product waste

This includes end-of-life products that have reached the end of their useful life or are no longer wanted by the consumer. These products can be collected, disassembled, and their components or materials can be reused, repaired, or recycled.

It is also an approach where companies implement comprehensive strategies to efficiently manage wastes from their origin until their final disposal. Possible waste disposal methods are recycling, composting, incineration, landfills, bioremediation, waste to energy, and waste minimization.

***Figure 5**. Type of product waste*

Production waste

This refers to waste generated during the manufacturing process, such as offcuts, excess materials, or by products. In a circular economy, efforts are made to minimize production waste and find ways to integrate it back into the production cycle or use it as inputs for other processes.

Overproduction:

Overproduction is the most obvious form of manufacturing waste. Not only does it lead to depleted raw materials, but also to wasted storage and excess capital tied up in unused products.

If you consistently overproduce, you may be forced to dispose of your product which can have a serious environmental impact. The process of disposal also creates wasted human effort and can pose the risk of exposing your workers to harmful waste materials.

The aim is to only produce what is required by the customer. Lean production relies on the 'just-in-time' principle, meaning your product should be created at the time it is needed, and not before.

Inventory:

This is the waste that is associated with unprocessed inventory. This includes the waste capital tied up in excess stock, wasted transport used moving the inventory, the light, and heating used to store the capacity and the containers used to store the excess product. Excess inventory can also hide other forms of inefficiencies that are produced by your current workflows.

Defects:

Defects refer to a product not meeting the specifications expected by the customer. Defects lead to a huge waste of time, starting in the form of paperwork. The product then needs to be disposed of and reproduced, which also costs time and money. Defects also lead to lost customers and reputation. It is, therefore, an exponentially costly form of waste.

Motion:

Motion wastage is any movement made that could have been used for another purpose. This results in a form of wastage as it is unnecessary energy and time. Wasted motion can be anything from a factory worker bending over to pick something up, to an unnecessary trip made by a machine.

Over-processing:

Lean manufacturing relies on products delivering value to the customer, but not over-engineering any product. Any work that doesn't need to be done, shouldn't be done. Over-processing is essentially delivering more value than is needed by the customer.

Waiting:

This is any form of waiting that must be done by either staff or machinery to complete a task. This will frequently happen when one process along the production line takes longer than it needs to, resulting in wasted worker time. Employees can be paid when not being productive, and materials can be spoilt when waiting for production.

Transportation:

Transportation is the process of moving something from one place to another. Transportation itself does not add any value to the customer, so it should be minimized as much possible. This can be done by making plants closer together and minimizing the cost of transportation.

Post-consumer waste

Post-consumer waste, also known as post-consumer recycled material or post-consumer content, refers to waste or recyclable materials that have been used by consumers and then collected for recycling rather than being disposed of in a landfill or incinerated. This waste is generated after a product has served its intended purpose and has been discarded by the end user. Examples of post-consumer waste include items like used paper, cardboard, glass bottles, aluminium cans, plastic containers, and other products that are typically recyclable.

Figure 6. *Post-consumer waste*

Post-consumer waste is an important resource for recycling and environmental sustainability. When these materials are collected, processed, and re-manufactured into new products, it helps reduce the demand for virgin raw materials, conserving natural resources and energy. It also minimizes the environmental impact associated with extracting, refining, and processing raw materials. Recycling post-consumer waste is a key component of efforts to reduce waste, conserve resources, and promote a more circular economy.

Biological waste

Biological waste, also known as biohazardous waste or biomedical waste, refers to waste materials that are potentially contaminated with biological agents such as bacteria, viruses, and other microorganisms that can pose a threat to human health or the environment. This category of waste includes various materials generated in healthcare settings, laboratories, and research facilities, as well as some specific waste streams from industries or households.

Biological waste may include items such as:

Medical waste: This includes used needles, syringes, bandages, cultures, tissues, blood and blood products, and other items that come into contact with bodily fluids or tissues.

Laboratory waste: Waste generated in research or clinical laboratories, which may include chemical reagents, cultures, and laboratory equipment that has come into contact with biological materials.

Animal waste: Waste generated from animal research, including animal carcasses and bedding materials.


Contaminated personal protective equipment (PPE): Used gloves, gowns, masks, and other PPE that may have come into contact with infectious materials.


Microbiological cultures: Petri dishes and test tubes containing bacteria or other microorganisms.

Pathological waste: Human or animal tissues and organs removed during medical procedures or autopsies.


Sharps' waste: Needles, scalpel blades, and other sharp objects that can puncture the skin and potentially transmit infections.

Proper disposal of biological waste is crucial to prevent the spread of infectious diseases and protect both healthcare workers and the general public. It typically involves specialized treatment and disposal methods, such as incineration, autoclaving (sterilization under high pressure and temperature), or chemical treatment, to ensure that the waste is rendered non-infectious. These procedures vary depending on local regulations and guidelines.

Biological waste management is highly regulated in many countries to ensure that it is handled safely and responsibly, with the goal of minimizing the potential risks associated with hazardous biological materials.

LECTURE 2
SOURCES OF WASTE DURING MANUFACTURING PROCESSES OF THE FOOTWEAR

2.1. INTRODUCTION

The shoe industry, also known as the footwear industry, plays a significant and multifaceted role on a global scale. Its importance is evident across various aspects, including economic, social, cultural, and environmental. Here are some key points highlighting the importance of the shoe industry globally:

Economic Impact:

Job Creation: Revenue Generation: The global shoe industry generates substantial revenue and contributes to the economic growth of many countries. It encompasses a wide range of businesses, from small-scale artisans to large multinational corporations.

Export and Trade: Many countries export footwear, contributing to international trade. Footwear is a valuable export commodity, and it can be a significant source of foreign exchange earnings.

Fashion and Culture:

Fashion and Style: Footwear is an essential fashion accessory, and trends in shoe design often mirror broader fashion trends. Shoes can be a symbol of personal style and cultural identity.

Cultural Significance: Different cultures have unique traditions and customs related to footwear. For example, certain shoe styles are associated with specific ceremonies or cultural practices.

Foot Health and Comfort:

Foot Health: Proper footwear is important for foot health and comfort. Quality shoes that provide support and fit well can help prevent foot problems and enhance overall well-being.

Innovation and Technology:

Technological Advancements: The footwear industry has seen significant technological advancements, leading to the development of comfortable, durable, and performance-enhancing shoes. Innovations in materials, cushioning, and design have been driven by both athletic and everyday footwear.

Environmental and Ethical Concerns:

Environmental Impact: The industry has a substantial environmental footprint, particularly concerning the production and disposal of shoes. Sustainable and eco-friendly practices are becoming increasingly important as the world grapples with environmental issues.

Consumer Choice and Behaviour:

Consumer Preferences: Footwear is a consumer-driven industry, and consumer preferences are continually changing. As consumers become more conscious of sustainability and ethical concerns, the industry is adapting to meet these demands.

Medical and Athletic Needs:

Medical Orthopaedics: Specialized medical and orthopaedic footwear plays a crucial role in helping individuals with foot conditions or injuries regain mobility and comfort.

Sports Performance: Athletic footwear is essential for athletes and active individuals, helping to enhance sports performance and reduce the risk of injuries.

In summary, the shoe industry is not only a major economic force but also a cultural, fashion, and health-related industry. It influences the daily lives of people around the world, from the shoes they wear for comfort and style to those designed for specific activities and needs. As the industry faces challenges related to sustainability and ethical manufacturing, it continues to evolve to meet the changing expectations of consumers and address global concerns.

In recent years, there has been a growing emphasis on **sustainable and responsible manufacturing in the footwear industry**. Many companies are focusing on reducing waste, using eco-friendly materials, and improving labour conditions. Additionally, consumers are increasingly looking for sustainable and ethically produced footwear products. This shift in consumer preferences is driving change in the industry, with more companies working towards reducing their environmental and social footprint.

2.2. WASTE DURING MANUFACTURING PROCESSESOF FOOTWEAR

***Figure 7**. Footwear and waste*

But what impacts are these shoes having on the planet, and how are we designing differently?

Figure 8. *The footwear industry has a substantial environmental footprint*

Footwear is a growing multi-billion-dollar industry heavily reliant on the over-consumption of products made from unsustainable materials. This comes at a high social and environmental cost with footwear being responsible for 1.4% of global greenhouse emissions.

The vast majority of shoes contain plastics which don't biodegrade. Indeed, the degradation of synthetic soles is the 7th biggest contributor to microplastic pollution.

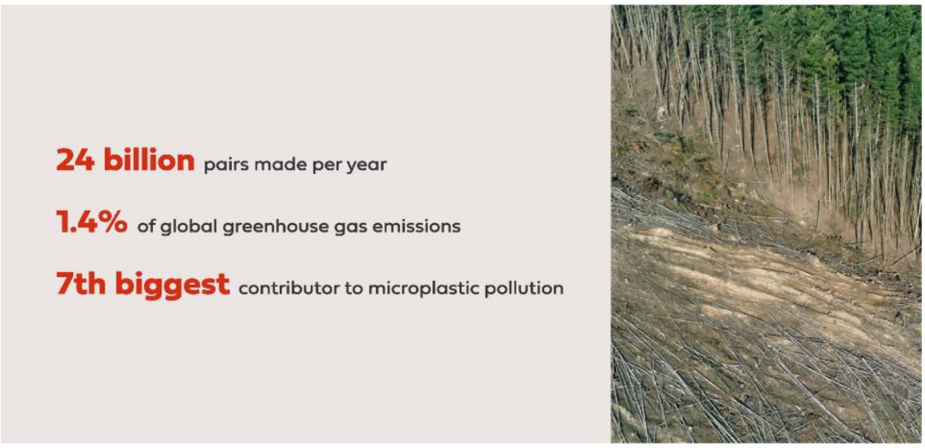


Figure 9. *Footwear global impact. Source: https://mcusercontent.com/9e9d43c0c9e653e34aae72f85/images/881cd44e-6070-0c1e-9b5f-b8337de4dc49.png*

Many of these plastics are hidden. Others are combined with bio-polymers, lessening the raw material impact, though commonly still not being biodegradable once processed. Leather is used extensively in footwear too. The production of which is catastrophic for the environment in terms of deforestation, biodiversity loss and greenhouse gas emissions. And although tanning methods are improving, the majority are still extremely water intensive rely on harmful chemicals.

Footwear industries are one of the largest producers of solid waste. The necessary resources that are used for the footwear manufacturing are leather, synthetic mate-rials, textile materials and rubber. The current fashion trends in the footwear sector have led to relatively decreasing the life of the shoes and footwear, which resulted in rapid market changes. To fulfil the needs of customers and be competitive in the global market, footwear manufacturers should follow and face two essential challenges: they should be quick to adapt the market changes and stay updated and relevant to establish new consumer trends. Mass production of footwear for different occasions and activities has started as per consumers demands. This led the consumers to buy more pairs of shoes at different times. These factors lead to the shorter life cycle of the footwear or shoes, also shorter product development cycle. This action generates a large amount of damaged and rejected shoes or footwears when their useful life has ended, leading to a higher level of the end of life. Post-consumer waste management is an exceptionally perplexing issue which is comprised of various segments.

2.3. SOURCES OF WASTE DURING MANUFACTURING PROCESSES OF THE FOOTWEAR

Waste is generated at various stages of the footwear manufacturing process. The sources of waste during the manufacturing of footwear can vary depending on the materials and production methods used.

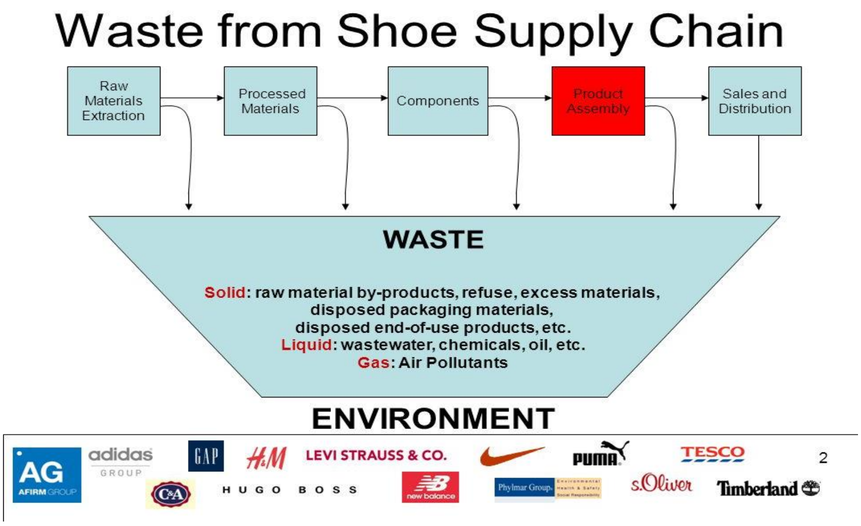


Figure 10. *Footwear waste.*
Source: https://slideplayer.com/slide/1550135/5/images/2/Waste+from+Shoe+Supply+Chain.jpg

Material waste

The cutting and shaping of various materials such as leather, synthetic fabrics, rubber, and foam result in leftover scraps and trimmings that can be considered waste if not utilized efficiently. Shoes are made from a combination of vinyl, leather, plastic and a host of other materials and take anywhere from 25-40 years to decompose in a landfill. This length of time paired with the estimated 300 million pairs of shoes discarded each year means that landfills are inundated with shoes.

Figure 11. *Footwear material waste. Source: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcSTzc61ZSZN3Xom6kuSKeHM-8BC_mQHtwt1uQ&usqp=CAU*

The most common material waste is the following:

Cutting and Trimming: When cutting patterns from sheets of materials, such as leather, fabric, or synthetic materials, there is often unused or leftover material that becomes waste.

Irregular Shapes: Some materials may have irregular or unusable shapes, resulting in wasted material

Die Cutting: In mass production, die-cutting methods can result in significant material waste due to the space between die cuts

Injection Molding: In the production of footwear components like soles, injection molding can generate waste in the form of runners (excess material that flows through channels in the mold).

Die Cutting Tools: Over time, cutting tools, such as dies, may become dull and less efficient, resulting in more waste and discarded tools.

Sanding and Finishing: The sanding and finishing processes can create dust and particulate waste, which may need to be collected and properly disposed of.

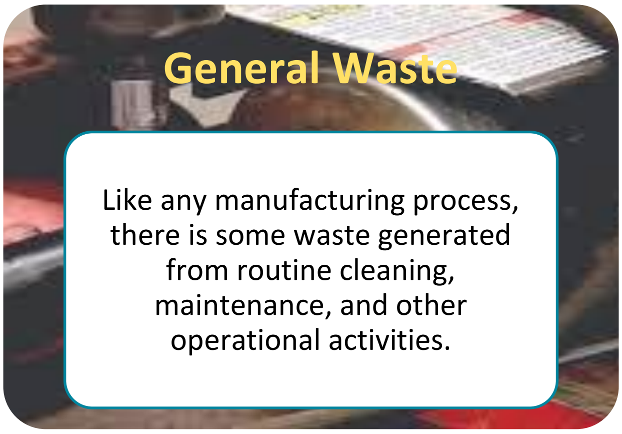
Trimming Components: Trimming excess material or removing seams can generate waste, particularly in the assembly of different shoe components.

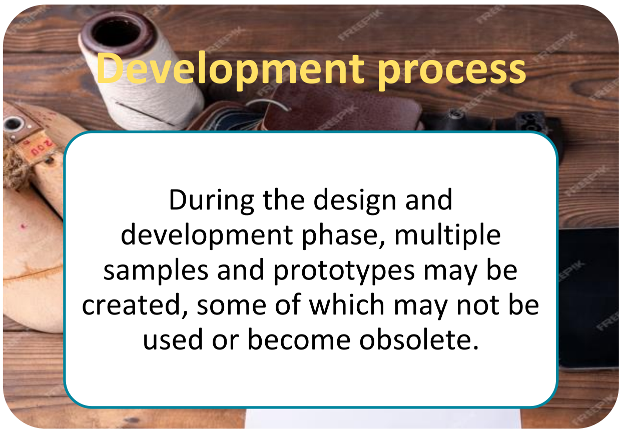
General manufacturing waste

An unfortunate but inevitable result of the production process is waste.

Figure 12. *Manufacturing waste*

Types of manufacturing waste:





Excess packaging

Footwear products often come with packaging materials such as boxes, inserts, tissue paper, plastic wrapping, and labels. If these materials are not designed with sustainability in mind or are excessive, they contribute to waste generation. Excess packaging in the footwear industry refers to the use of more packaging materials than necessary to package and protect shoes during storage, transportation, and sale. This issue has gained attention due to environmental concerns, as excessive packaging can contribute to waste and environmental degradation.

Figure 13. *Packaging Waste.*
Source: https://ecorite.com/wp-content/uploads/2021/02/ecorite-20210226.jpg

Here are some key aspects related to excess packaging in the footwear industry:

Environmental Impact:

<u>Waste Generation</u>: Excess packaging leads to more waste in the form of cardboard, plastics, and other materials. This waste often ends up in landfills, contributing to environmental issues.

<u>Resource Consumption</u>: The production of packaging materials consumes resources, including energy and raw materials, which can strain natural resources and contribute to greenhouse gas emissions.

Carbon Footprint: The transportation of shoes in excessively packaged boxes or containers can increase the carbon footprint of the footwear industry due to the added weight and space required for shipping.

Consumer Perception:

Wasteful Image: Companies that use excessive packaging may be perceived as wasteful or environmentally irresponsible by consumers. This can lead to negative public relations and affect brand image.

Consumer Preferences: Many consumers prefer products with minimal, eco-friendly packaging. Brands that align with these preferences may have a competitive advantage.

Economic Costs:

Increased Costs: Excessive packaging can increase a company's packaging and shipping costs. This can impact a company's profitability, particularly if the costs are not justified.

Space and Storage:

Storage Challenges: Retailers and consumers may face difficulties in storing or disposing of excessive packaging, which can lead to logistical challenges.

Chemical waste

Chemical waste in the footwear industry is a significant environmental concern, particularly in processes such as tanning, dyeing, adhesives, and finishing. Chemicals are essential in various stages of footwear manufacturing, but if not managed properly, they can have adverse environmental and health effects. Here are some key aspects of chemical waste in the footwear industry:

***Figure 14**. Leather chemical waste.*
Source: https://leatherpanel.org/sites/default/files/publications-images/pict0199.jpg

Tanning Process:

Hazardous Chemicals: Tanning leather often involves the use of hazardous chemicals, such as chromium, which can pose risks to both workers and the environment if not properly controlled.
Wastewater Contamination: Improper disposal of wastewater from the tanning process can contaminate water sources and soil with harmful chemicals, affecting ecosystems and human health.

Dyeing and Colouring:
Chemical Dyes: Dyeing processes require the use of chemical dyes, which can contain substances harmful to the environment. Improper disposal of dye chemicals can result in water pollution.

Adhesive Use:
Volatile Organic Compounds (VOCs): Some adhesives used in the footwear industry can contain VOCs, which can contribute to air pollution and impact indoor air quality for workers.

Finishing and Coating:
Solvents: Finishing and coating processes often involve the use of solvents, which can release harmful fumes and contribute to air pollution if not managed properly.

Chemical Waste Disposal:
Improper Disposal: If chemical waste is not properly managed and disposed of, it can contaminate soil and water or lead to unsafe conditions for workers and surrounding communities.

Energy waste

Inefficient energy usage during manufacturing processes, such as excessive heating or cooling, inadequate insulation, or outdated machinery, can result in energy waste.
Inefficient energy usage during the manufacturing processes in the footwear industry can have several negative consequences, including increased operating costs, higher carbon emissions, and reduced competitiveness. Energy consumption is a significant concern in manufacturing, and the footwear industry is no exception. Here are some key factors contributing to inefficient energy usage in footwear manufacturing and steps that can be taken to address these issues:

Factors Contributing to Inefficient Energy Usage:
Outdated Machinery: The use of older, energy-inefficient machinery can result in high energy consumption.
Ineffective Production Layout: Poorly designed production layouts can lead to inefficiencies, with excessive movement of materials and products that consume extra energy.

Lack of Energy-Efficient Technologies: Failing to invest in modern, energy-efficient technologies can result in higher energy consumption.
Inadequate Maintenance: Neglecting regular maintenance of machinery can lead to decreased efficiency and increased energy usage.
Overproduction: Overproduction of footwear products can result in wasted energy as more materials and labour are used than necessary.

Water waste

Footwear manufacturing requires significant amounts of water for processes like cleaning, dyeing, and finishing. If water is not managed properly, it can be wasted through leakage, improper treatment, or inefficient use. Water waste in the footwear industry refers to the excessive and inefficient use of water in various manufacturing processes, such as tanning, dyeing, and finishing. Water waste has environmental, economic, and social implications and is a significant concern in industries that rely on water-intensive processes. Here are some of the key factors contributing to water waste in the footwear industry and steps that can be taken to address these issues:

Factors Contributing to Water Waste:

Leather Tanning: The leather tanning process can be water-intensive, especially when traditional methods are used. Tanneries often consume substantial amounts of water.
Dyeing and Colouring: Dyeing and coloring processes require significant volumes of water to achieve the desired color and finish.
Wastewater Treatment: Inadequate or inefficient wastewater treatment processes can lead to water waste, as untreated or poorly treated water cannot be reused.
Water-Intensive Materials: The use of water-intensive materials in footwear production, such as cotton or natural fibers, can contribute to increased water consumption.
Inefficient Equipment: Older and outdated machinery may not be designed for water efficiency, leading to water wastage during the manufacturing process.

Defective products

Defective products in the footwear industry refer to shoes or footwear items that do not meet the expected quality and safety standards. The presence of defective products can result in several negative consequences for both consumers and footwear manufacturers. Here are some key aspects related to defective products in the footwear industry and steps that can be taken to address these issues:

Causes and Consequences of Defective Products:

Production Errors: Mistakes or errors during the manufacturing process can lead to defects, such as misaligned seams, incorrect sizing, or missing components.
Design Flaws: Defective products can also result from design flaws that compromise the fit, comfort, or durability of the footwear.
Material Quality Issues: The use of substandard or low-quality materials in production can lead to defects, such as poor stitching, weak soles, or easily damaged uppers.
Inadequate Quality Control: Lax quality control measures or insufficient inspections can allow defective products to pass through the production process and reach the market.

LECTURE 3
MANAGEMENT OF HAZARDOUS WASTE IN THE FOOTWEAR INDUSTRY

3.1. INTRODUCTION

Managing hazardous wastes in the footwear industry is crucial to ensure environmental sustainability and compliance with regulations. The production of footwear involves various processes that can generate hazardous waste, including chemicals, solvents, and other materials.
Within the possible categories of industrial solid wastes, the generation of shoe manufacturing wastes in particular is perceived as a significant waste stream, both from a qualitative and a quantitative point of view. Various types of materials, including leathers, synthetic and natural rubbers, fabrics, and cellulose-based and wood materials, constitute the basic components commonly used in shoe manufacturing (Staikos et al., 2006, Staikos and Rahimifard, 2007a). Consequently, diverse environmental concerns are linked with the management of the corresponding manufacturing wastes.

3.2. MANAGEMENT OF WASTE HAZARDOUS MATERIALS

Here are some key steps and considerations for the management of hazardous wastes in the footwear industry:

Identification

The footwear industry involves various processes, from the production of raw materials to the manufacturing of finished shoes. Throughout these processes, several hazardous materials are commonly used. It's important to note that the specific hazardous materials can vary depending on the type of footwear, manufacturing processes, and the materials used. Here are some general categories of hazardous materials commonly found in the footwear industry:

Chemical Adhesives:

Solvent-based adhesives often contain volatile organic compounds (VOCs) that can be hazardous to human health and the environment.

Solvents:

Various solvents are used in the footwear industry for cleaning, degreasing, and adhesive applications. Examples include toluene, acetone, and ethyl acetate.

Finishing Agents:

Chemicals used in the finishing process, such as dyes, coatings, and waterproofing agents, may contain hazardous substances.

Leather Treatment Chemicals:

Leather, a common material in footwear, undergoes various chemical treatments, including tanning processes that use chemicals like chromium salts, which can be hazardous.

Rubber Processing Chemicals:

Chemicals used in the processing of rubber, such as vulcanizing agents and accelerators, can pose health and environmental risks.

Metallic Compounds:

Some footwear components may contain metallic compounds, such as chromium or lead, which can be hazardous if not handled properly.

Plasticizers:

Plasticizers are used in certain materials to impart flexibility. Phthalates, commonly used as plasticizers, can be hazardous and have been subject to regulatory scrutiny.

Biocides and Antimicrobial Agents:

Footwear may incorporate antimicrobial agents or biocides to prevent the growth of fungi and bacteria. These substances can have environmental implications.

Cyanides:

Cyanides may be used in certain processes, such as electroplating for decorative finishes, and they are hazardous if not properly managed.

Heavy Metals:

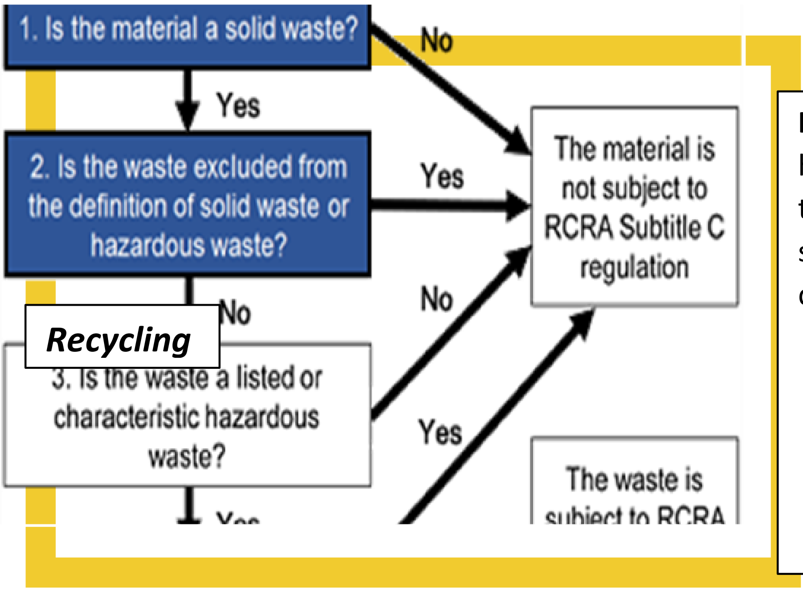
Some components, such as buckles or decorations, may contain heavy metals like cadmium or lead, which can be toxic.

Textile Chemicals:

Textile components in footwear may be treated with chemicals such as flame retardants, water repellents, and colorants, some of which can be hazardous.

Polyurethane Foams:

Some footwear includes polyurethane foams, which may contain isocyanates during the manufacturing process. Isocyanates can be respiratory irritants and require careful handling.



Identification: Identify the hazardous materials used in the manufacturing processes, such as adhesives, solvents, dyes, and finishing agents.

Figure 15. *Identification of waste. Source: https://www.epa.gov/hw/criteria-definition-solid-waste-and-solid-and-hazardous-waste-exclusions#tablesw*

It's essential for footwear manufacturers to conduct thorough assessments of the materials and processes they use, considering potential health and environmental impacts. Compliance with regulations and industry standards for handling, disposal, and reporting of hazardous materials is crucial to ensure the safety of workers and reduce the environmental footprint of the footwear industry. Additionally, adopting alternative materials and cleaner production processes can contribute to a more sustainable and environmentally friendly approach within the industry.

Classification

Classifying hazardous materials in the footwear industry is crucial for compliance with local and international regulations. Various regulatory frameworks exist globally, and classifications may differ between regions. Below are general classifications based on common regulatory systems:

Local and International Classifications:

Globally Harmonized System (GHS): The GHS is an international system that standardizes the classification and labelling of chemicals. Hazardous materials are classified into categories such as:

- Physical hazards (e.g., flammable, explosive)
- Health hazards (e.g., carcinogenic, toxic)
- Environmental hazards

Environmental Protection Agency (EPA):

The EPA regulates the environmental impact of hazardous materials. It may classify materials as hazardous waste under the Resource Conservation and Recovery Act (RCRA).

European Union (EU) Regulations:

Classification, Labelling, and Packaging (CLP) Regulation:

The CLP Regulation in the European Union aligns with the GHS and classifies substances and mixtures based on their hazards.

REACH Regulation:

The Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) Regulation addresses the production and use of chemicals. It includes the classification of substances based on their intrinsic properties.

Hazardous Waste Regulations:

Basel Convention:

The Basel Convention regulates the transboundary movements of hazardous wastes and their disposal. It aims to minimize the generation of hazardous wastes and promote environmentally sound management.

Local Waste Regulations:

Countries have specific regulations governing the disposal and management of hazardous waste. These may include requirements for proper labelling, storage, and disposal methods.

Classification: Classify these materials according to local and international regulations to determine the level of hazard they pose.

***Figure 16**. Waste Classification. Source: https://mlienvironmental.com/blog/classes-of-hazardous-materials/*

Recommendations for Footwear Industry:

- Conduct a thorough assessment of the chemicals and materials used in manufacturing processes.
- Ensure compliance with local and international regulations related to chemical handling, storage, and disposal.
- Provide appropriate training for workers on the hazards of materials used and proper handling procedures.

- Implement proper labelling and documentation practices, including safety data sheets (SDS).
- Stay informed about updates to regulations and adjust practices accordingly.
- It's essential for footwear manufacturers to stay updated on specific regulations in their regions and to work closely with regulatory bodies to ensure compliance and the safe handling of hazardous materials throughout the product lifecycle.

Waste minimization

Waste minimization in the footwear industry is a critical aspect of sustainable manufacturing. By implementing effective waste reduction strategies, companies can reduce environmental impact, lower production costs, and enhance overall sustainability.

Figure 17. *Waste minimization. Source: https://www.unsustainablemagazine.com/global-shoe-waste/*

Material Efficiency and Design for Sustainability:

Optimize Cutting Processes: Implement precision cutting technologies and techniques to minimize material waste during the manufacturing of shoe components.

Pattern Optimization: Design shoe patterns to maximize material utilization and reduce offcuts.

Lean Manufacturing Principles:

Streamline Production: Adopt lean manufacturing principles to eliminate unnecessary steps, reduce excess inventory, and improve overall production efficiency.

Kaizen Practices: Encourage continuous improvement through Kaizen practices to identify and address sources of waste in real-time.

Closed-Loop Systems and Recycling:

Recycling Initiatives: Establish partnerships with recycling facilities to recycle materials such as rubber, leather, and plastics used in footwear manufacturing.

Closed-Loop Systems: Explore opportunities for closed-loop systems where waste materials from one stage of production become inputs for another.

Efficient Inventory Management:

Just-In-Time (JIT) Inventory: Implement JIT principles to minimize excess raw material inventory and reduce the risk of waste due to material obsolescence.

Supplier Collaboration: Work closely with suppliers to ensure efficient inventory management and prevent over-ordering.

Product Take-Back Programs:

End-of-Life Considerations: Design footwear with end-of-life considerations, and establish take-back programs to collect used shoes for refurbishment, recycling, or donation.

Energy Efficiency:

Energy Audits: Conduct regular energy audits to identify opportunities for reducing energy consumption in manufacturing processes.

Renewable Energy Sources: Transition to renewable energy sources to power manufacturing facilities.

Packaging Optimization:

Minimalist Packaging: Optimize product packaging to reduce material usage without compromising product protection.

Sustainable Packaging: Choose eco-friendly packaging materials that are recyclable or biodegradable.

Life Cycle Assessment (LCA):

LCA Analysis: Conduct a life cycle assessment to identify environmental impacts throughout the product life cycle and inform decisions on waste reduction strategies.

Collaboration with Stakeholders:

Supplier Engagement: Collaborate with material suppliers to promote sustainable practices and reduce packaging waste.

Consumer Education:

Educate consumers about the environmental impact of their choices and the importance of responsible disposal and recycling of footwear products.

By integrating these waste minimization practices into their operations, footwear manufacturers can contribute to a more sustainable industry while improving operational efficiency and reducing costs. Continuous monitoring, assessment, and adaptation of waste reduction strategies are key to long-term success in minimizing waste in the footwear sector.

Storage and Segregation

The storage and segregation of hazardous materials in the footwear industry are critical aspects of safety, compliance with regulations, and environmental responsibility. Proper handling of hazardous materials ensures the well-being of employees, minimizes environmental impact, and helps companies comply with local and international regulations. Here are guidelines for the storage and segregation of hazardous materials in the footwear industry:

***Figure 18**. Segregation and storage*

Storage Guidelines:

Designated Storage Areas:

Establish clearly designated storage areas for hazardous materials. These areas should be well-ventilated, secure, and equipped with proper containment measures.

Segregation from Incompatible Materials:

Separate hazardous materials based on their compatibility to prevent chemical reactions. For example, acids should be stored separately from bases, and flammable materials should be kept away from oxidizers.

Proper Ventilation:

Ensure that storage areas have adequate ventilation to prevent the accumulation of fumes or vapors. Install ventilation systems if necessary.

Temperature Control:

Store hazardous materials at appropriate temperatures to prevent reactions or degradation. Follow storage requirements specified on material safety data sheets (MSDS) or safety data sheets (SDS).

Light Control:

Some materials are sensitive to light. Store light-sensitive hazardous materials in opaque containers or in areas protected from direct sunlight.

Labelling:

Clearly label all containers with the name of the hazardous material, associated hazards, and any other relevant information. This facilitates quick identification and safe handling.

Proper Shelving and Racking:

Use appropriate shelving and racking systems to organize and store hazardous materials safely. Ensure that shelves are sturdy and can handle the weight of the stored materials.

Secondary Containment:

Implement secondary containment measures, such as bunds or trays, to contain spills and leaks. This prevents the release of hazardous substances into the environment.

Emergency Equipment:

Keep emergency equipment, such as spill kits, fire extinguishers, and first aid supplies, readily accessible in or near storage areas.

Restricted Access:

Limit access to hazardous material storage areas to authorized personnel only. Implement control measures to prevent unauthorized entry.

Segregation Guidelines:

Chemical Compatibility:

Group hazardous materials based on their chemical compatibility to avoid reactions. Common segregation categories include acids, bases, oxidizers, flammables, and toxic substances.

Storage Classes:

Segregate materials based on storage classes, such as flammables, corrosives, and toxics. This helps prevent cross-contamination and facilitates efficient emergency response.

Separate Flammables:

Store flammable liquids in approved flammable storage cabinets or rooms with proper ventilation. Keep flammables away from heat sources and ignition points.

Isolate Incompatible Materials:

Identify materials that are incompatible with each other and ensure they are stored far apart. Common examples include storing acids away from bases to prevent reactions.

Color Coding:

Implement a color-coding system to visually distinguish between different types of hazardous materials. This aids in quick identification and proper segregation.

Segregation by Storage Conditions:

Consider storage conditions when segregating materials. For example, store materials that require refrigeration in separate areas from those that require ambient temperatures.

Regular Inspections:

Conduct regular inspections of storage areas to ensure that segregation and storage practices are maintained. Address any issues promptly.

Training and Awareness:

Provide training to employees on the importance of segregation, safe storage practices, and emergency response procedures.

Documentation:

Maintain accurate records of the hazardous materials stored, their quantities, and their locations. This documentation is essential for regulatory compliance and emergency response.

Emergency Response Plan:

Develop and communicate an emergency response plan that includes procedures for handling spills, leaks, or other incidents involving hazardous materials.

By adhering to these storage and segregation guidelines, the footwear industry can create a safer working environment, reduce the risk of incidents, and ensure compliance with regulatory requirements related to hazardous materials management. Regular training, ongoing monitoring, and continuous improvement efforts are essential components of a comprehensive hazardous materials management program.

Labelling and Documentation

Labelling and documentation of hazardous materials in the footwear industry are crucial aspects of regulatory compliance, workplace safety, and environmental responsibility. Proper labeling and documentation help ensure that employees, emergency responders, and regulatory authorities have the necessary information to handle hazardous materials safely. Here are guidelines for labeling and documenting hazardous materials in the footwear industry:

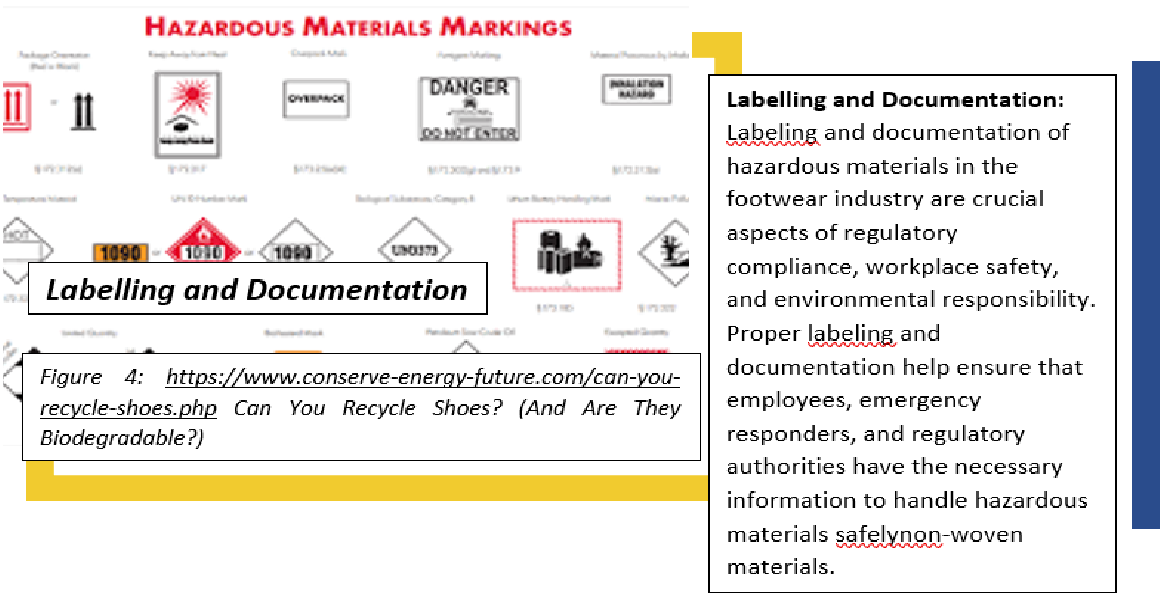


Figure 19. *Labelling and documentation*

Labelling Guidelines/ Labelling Requirements:

Adhere to local and international regulations regarding the labelling of hazardous materials. Regulations such as the Globally Harmonized System (GHS) provide standardized criteria for labelling.

Information on Labels: Include essential information on hazardous material labels, such as:

- Product or chemical name
- Hazard pictograms (according to GHS)
- Signal words (e.g., "Danger" or "Warning")
- Hazard statements and precautionary statements
- Manufacturer or supplier information
- Readability and Durability:

Ensure that labels are clear, legible, and durable. Labels should remain intact under normal storage and handling conditions.

Color Coding: Implement a color-coding system for labels to visually indicate the type of hazard. For example, red for flammable, yellow for reactive, and so on.

Label Placement: Affix labels prominently on containers or packages of hazardous materials. Ensure that labels are easily visible and accessible.

Secondary Containers: If transferring hazardous materials to secondary containers, maintain proper labelling on the secondary container to avoid confusion.

Employee Training: Train employees on how to read and interpret hazard labels. Ensure that they understand the significance of each element on the label.

Multilingual Labels: If applicable, use multilingual labels to accommodate a diverse workforce. Ensure that employees can understand hazard information regardless of their language proficiency.

Documentation Guidelines:

Safety Data Sheets (SDS): Maintain up-to-date SDS for all hazardous materials used in the footwear industry. SDS provides detailed information on the properties, hazards, and safe handling procedures for each substance.

SDS Accessibility: Keep SDS readily accessible to employees who may be exposed to hazardous materials. Store electronic or hard copies in designated areas.

Emergency Response Information: Include emergency response information in the documentation, specifying actions to take in the event of spills, leaks, or exposure incidents.

Record Keeping: Maintain accurate records of hazardous materials on-site, including quantities, locations, and dates of acquisition. These records are essential for regulatory compliance and emergency response planning.

Supplier Documentation: Obtain and keep documentation provided by material suppliers, including certificates of analysis, material specifications, and any additional safety information.

Inventory Tracking:

Implement an inventory tracking system to monitor the movement and usage of hazardous materials. Regularly update records to reflect changes in inventory.

Regulatory Compliance: Stay informed about changes in regulations related to hazardous materials and update documentation accordingly to ensure compliance.

Employee Training Records: Keep records of employee training related to hazardous materials, including the date of training, topics covered, and the names of trained individuals.

Waste Disposal Documentation:

Document the disposal of hazardous waste materials, including information on the disposal method, date, and disposal facility used.

Audit and Review:

Conduct regular audits of documentation to ensure accuracy and completeness. Review and update information as needed.

Integrated Systems:

Integrate labelling and documentation practices with overall management systems, such as ISO 14001 for environmental management or OHSAS 18001/ISO 45001 for occupational health and safety.

Continuous Improvement:
Establish processes for continuous improvement by regularly assessing labelling and documentation practices. Use feedback and lessons learned to enhance procedures.
By following these labelling and documentation guidelines, the footwear industry can maintain a safer workplace, facilitate emergency response efforts, and comply with regulatory requirements related to the handling and communication of hazardous materials. Regular training and awareness programs are integral to ensuring that employees are well-informed about the hazards associated with the materials they handle.

Employee Training

Provide training to employees on proper handling, storage, and disposal procedures for hazardous materials. Implement safety protocols and emergency response plans to address potential accidents or spills. Developing and delivering effective training on the proper handling, storage, and disposal of hazardous materials is crucial in ensuring the safety of employees in the footwear industry. Here is a comprehensive training outline for employees in the footwear industry:

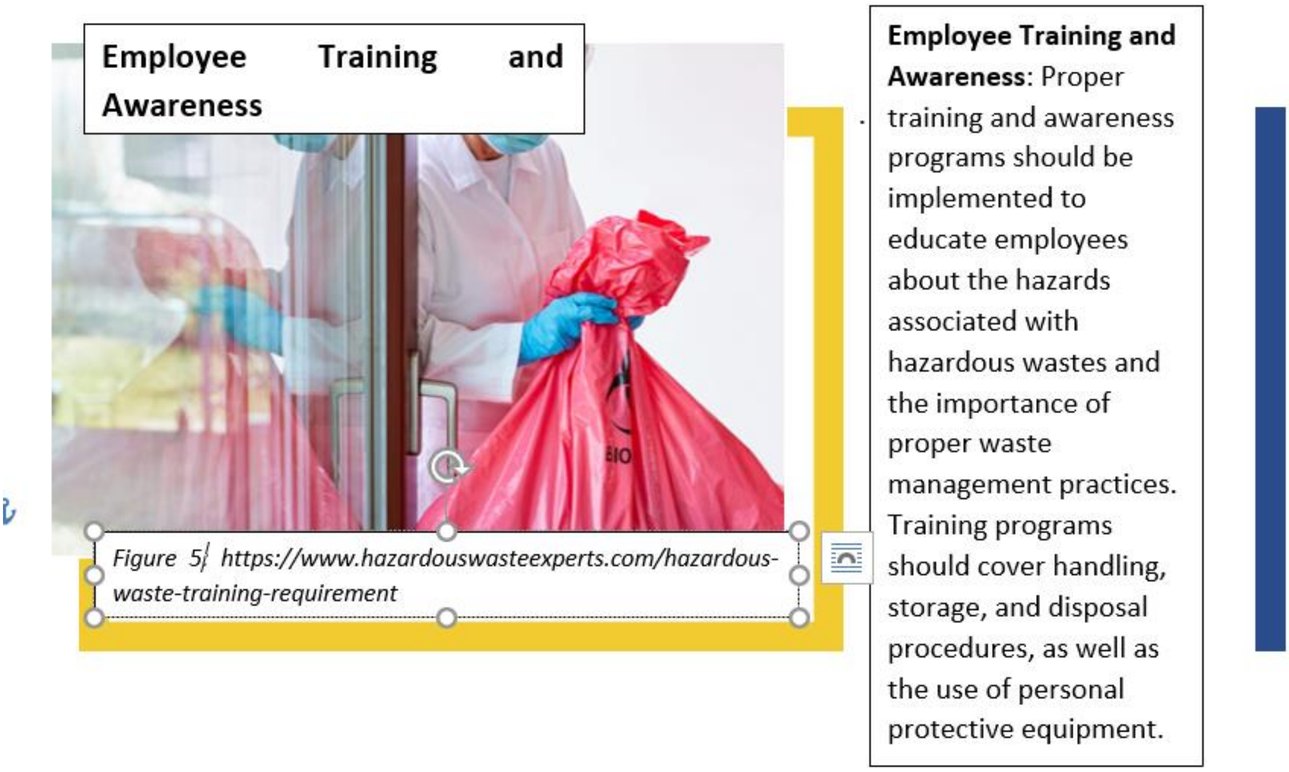


Figure 20. *Employee training and awareness*

Training Program Outline:

- Overview of Hazardous Materials
- Overview of local and international regulations (e.g., OSHA, GHS)

- Importance of compliance with regulatory requirements
- Hazard Identification and Labelling
- Understanding hazard communication signs and labels
- Globally Harmonized System (GHS)
- Safe Handling Practices
- Personal Protective Equipment (PPE)
- Handling Procedures:
- Storage Guidelines
- Segregation Practices
- Waste Management and Disposal
- Emergency Response
- Sustainable Practices

Waste Transportation

Waste transportation in the footwear industry involves the movement of various types of waste materials from manufacturing facilities to disposal or recycling sites. Proper waste transportation practices are essential to ensure compliance with regulations, protect the environment, and contribute to overall sustainability.

Figure 21. *Waste transportation*

Here are key considerations for waste transportation in the footwear industry:

1. Waste Characterization:

Identification of Waste Types: Clearly categorize and characterize different types of waste generated in the footwear industry, such as rubber scraps, leather offcuts, and packaging materials.

2. *Packaging and Containerization:*

Secure Packaging: Package waste securely to prevent spills or leaks during transportation.

Container Selection: Use containers that are suitable for the type of waste being transported and comply with transportation regulations.

3. *Labelling and Documentation:*

Hazardous Materials Labelling: Clearly label waste containers with appropriate hazardous materials labels, including information on the type of waste and associated hazards.

Transportation Manifests: Prepare and include necessary transportation manifests and documentation required by regulatory authorities.

4. Transportation Modes:

Selection of Transport Mode: Choose transportation methods based on the volume, type, and destination of waste. Options include trucks, specialized waste transporters, or third-party waste management services.

Compliance with Regulations: Ensure that all transportation activities comply with local, national, and international regulations governing the transport of hazardous and non-hazardous waste.

5. Handling and Loading:

Proper Handling Procedures: Train personnel involved in waste transportation on proper handling procedures to minimize the risk of accidents or spills.

Loading Practices: Load waste containers securely to prevent shifting during transportation. Ensure even weight distribution to maintain stability.

6. *Documentation and Record Keeping:*

Documentation Accuracy: Double-check and ensure the accuracy of all transportation documents, including manifests and any required permits.

Record Keeping: Maintain detailed records of waste transportation activities, including dates, quantities, and destinations.

7. *Emergency Response Planning:*

Emergency Kits: Equip transportation vehicles with emergency response kits containing spill cleanup materials, personal protective equipment, and first aid supplies.

Training: Provide training to transportation personnel on emergency response procedures in case of spills, accidents, or other incidents during transportation.

8. *Collaboration with Waste Management Providers*:

Partnerships: Collaborate with waste management providers and transporters experienced in handling specific types of waste from the footwear industry.

Communication: Maintain open communication with waste management partners to ensure smooth coordination in waste transportation activities.

9. *Sustainable Transportation Practices:*

Route Optimization: Optimize transportation routes to reduce fuel consumption, emissions, and overall environmental impact.

Alternative Fuels: Explore the use of alternative fuels or eco-friendly transport options to minimize the carbon footprint of waste transportation.

10. *Continuous Improvement:*

Regular Audits: Conduct regular audits of waste transportation processes to identify areas for improvement and ensure ongoing compliance.

Feedback Mechanism: Establish a feedback mechanism to receive input from personnel involved in waste transportation for continuous improvement.

11. *Community Engagement:*

Community Awareness: Engage with local communities to inform them about waste transportation activities, address concerns, and demonstrate a commitment to responsible waste management.

Effective waste transportation practices in the footwear industry contribute to overall environmental sustainability and regulatory compliance. Regular training, adherence to best practices, and continuous improvement efforts are crucial for maintaining a safe and efficient waste transportation process.

2.1.2.8 Treatment and Recycling

The treatment and recycling of hazardous materials play a crucial role in minimizing environmental impact, conserving resources, and promoting sustainable practices. In the footwear industry, where various materials and chemicals are used, proper treatment and recycling methods help reduce the overall environmental footprint.

Figure 7: https://www.youtube.com/watch?v=D8jfLf_bODs

Treatment and Recycling: Hazardous wastes from the footwear industry may require treatment before final disposal. Treatment methods can include physical, chemical, or biological processes to neutralize or detoxify the wastes. The choice of treatment method depends on the specific waste characteristics. Disposal should be carried out in accordance with local regulations and can include options such as incineration, landfilling, or recycling.

Figure 22. *Treatment and recycling*

Here are key considerations for the treatment and recycling of hazardous materials:

1. **Waste Characterization:**

   Identify and Categorize Waste: Conduct a thorough assessment to identify different types of hazardous materials generated in the footwear industry, including chemicals, solvents, and waste from manufacturing processes.

2. **Segregation of Hazardous Materials:**

   Segregate Materials at Source: Implement a segregation system to separate hazardous materials based on their characteristics, allowing for targeted treatment and recycling.

3. **Chemical Treatment:**

   Neutralization: Use appropriate chemical treatments to neutralize hazardous substances, making them less harmful.

   Chemical Recovery: Explore technologies for recovering valuable chemicals from waste streams for reuse within the manufacturing process.

4. **Physical Treatment Methods:**

   Filtration and Separation: Employ filtration and separation techniques to remove contaminants from liquids and gases.

   Centrifugation: Use centrifugation to separate materials based on density, facilitating the recovery of valuable components.

5. **Biological Treatment:**
   Bioremediation: Consider biological treatment methods, such as bioremediation, to degrade or transform hazardous substances into less harmful forms.
   Composting: Explore composting as a method for treating organic waste materials.
6. **Incineration:**
   High-Temperature Incineration: Incinerate certain hazardous materials at high temperatures in controlled environments to reduce their volume and eliminate toxins.
   Energy Recovery: Implement waste-to-energy technologies to recover heat or electricity from incinerated materials.
7. **Recycling of Materials:**
   Rubber and Plastics Recycling: Explore recycling methods for rubber and plastics used in footwear production.
   Metal Recovery: Recover metals from waste materials, such as metal components used in footwear, through recycling processes.
   Textile Recycling: Investigate recycling options for textile waste generated in the manufacturing process.
8. **Closed-Loop Systems:**
   Circular Economy Practices: Embrace circular economy principles by establishing closed-loop systems where materials are recycled and reintroduced into the manufacturing process.
9. **Waste-to-Energy (WtE):**
   Energy Recovery: Consider Waste-to-Energy technologies that convert non-recyclable waste into heat, electricity, or fuel.
   Environmental Impact: Evaluate the environmental impact and feasibility of WtE options, balancing energy recovery with emissions reduction.
10. **Recovery of Valuable Components:**
   Extraction of Valuables: Investigate methods to extract valuable components, such as precious metals or chemicals, from waste materials.
11. **Compliance with Regulations:**
   Environmental Regulations: Ensure that treatment and recycling practices comply with local, national, and international environmental regulations.
   Permitting: Obtain necessary permits for hazardous waste treatment facilities and recycling operations.
12. **Continuous Monitoring and Improvement**:
   Performance Monitoring: Continuously monitor the effectiveness of treatment and recycling processes through regular assessments.
   Innovation: Stay abreast of technological advancements and innovative solutions in hazardous material treatment and recycling.

13. **Public Outreach and Communication:**

    Transparency: Communicate transparently with stakeholders, including employees, local communities, and consumers, about the company's efforts in hazardous material treatment and recycling.

14. **Collaboration with Industry Partners:**

    Industry Collaboration: Collaborate with industry partners, waste management companies, and research institutions to share best practices and promote collective efforts in sustainable waste management.

Implementing effective treatment and recycling practices for hazardous materials in the footwear industry requires a comprehensive and integrated approach. By incorporating these considerations, companies can contribute to a more sustainable and environmentally friendly manufacturing process. Regular monitoring, compliance with regulations, and a commitment to continuous improvement are essential components of a successful hazardous waste management strategy.

Compliance with regulations

Periodically review and update waste management practices based on technological advancements and changes in regulations. Seek opportunities to improve efficiency, reduce waste generation, and enhance sustainability in the footwear manufacturing process. By adopting a comprehensive approach to hazardous waste management, the footwear industry can contribute to environmental protection and sustainable development while ensuring compliance with regulatory requirements.

Figure 8: www.heritage-enviro.com/15-point-summary-containerized-hazardous-waste-regulations/

Compliance with regulations:

The management of hazardous wastes in the footwear industry must adhere to relevant local, national, and international regulations. These regulations govern the handling, transportation, treatment, and disposal of hazardous materials. It is important for footwear manufacturers to stay updated on the latest regulations and ensure compliance to avoid legal and environmental liabilities.

Figure 23. *Compliance and regulations*

Waste management regulations in the shoe industry vary from country to country, but generally, they aim to minimize the environmental impact of shoe manufacturing and disposal. Here are some common waste management practices and regulations in the shoe industry:

Hazardous Materials Management: Shoe manufacturing involves the use of various chemicals, including adhesives, dyes, and solvents. Waste management regulations require proper handling, storage, and disposal of these hazardous materials to prevent contamination of soil, water, and air. Manufacturers must adhere to specific guidelines for the storage, labelling, and transportation of these substances.

Waste Reduction and Recycling: Many countries have waste reduction targets and encourage shoe manufacturers to minimize waste generation by adopting sustainable practices. This includes promoting the use of recycled materials in shoe production, implementing recycling programs for scrap materials, and exploring ways to reduce packaging waste.

Product Stewardship: Product stewardship refers to the responsibility of shoe manufacturers for the entire lifecycle of their products, including their disposal. Some regulations require shoe companies to develop and implement take-back programs, where consumers can return their old shoes for proper recycling or disposal. This helps prevent shoes from ending up in landfills and encourages resource recovery.

Extended Producer Responsibility (EPR): EPR is a policy approach where shoe manufacturers take responsibility for the environmental impacts of their products throughout their lifecycle. It often involves financial and logistical obligations for managing the collection, recycling, and safe disposal of shoes. EPR regulations encourage manufacturers to design products that are more easily recyclable and promote the establishment of collection infrastructure.

Waste Water Management: The shoe manufacturing process can generate wastewater containing pollutants such as chemicals, dyes, and heavy metals. Waste management regulations require treatment of this wastewater to remove or minimize contaminants before it is discharged into water bodies. Compliance with wastewater treatment standards is crucial for minimizing environmental pollution.

Reporting and Compliance: Shoe manufacturers may be required to report on their waste management practices and compliance with regulations. This includes keeping records of waste generation, recycling rates, and the proper handling of hazardous materials. Regular audits and inspections by regulatory authorities help ensure adherence to waste management regulations.

Waste management regulations can change over time, and new developments may have occurred since this last update. Therefore, it is advisable to consult the specific regulations and guidelines provided by the relevant authorities in your country or region to obtain the most up-to-date and accurate information

LECTURE 4
VALORISATION OF WASTE MATERIAL

4.1. INTRODUCTION

"Waste valorisation" refers to the process of extracting value from waste materials, often by converting them into new products, energy, or resources. When waste is not only collected but also valorised, it completes the waste management cycle. Waste valorisation completes the waste management cycle by extracting value from discarded materials, contributing to resource conservation, environmental sustainability, economic development, and community engagement. It represents a more holistic and sustainable approach to managing waste beyond mere collection and disposal.

The valorisation of waste resulting from footwear manufacturing involves finding ways to extract value from these waste materials rather than simply disposing of them. This approach contributes to sustainability, resource efficiency, and potentially reduces environmental impact.

4.2. WHY VALORISATION IS IMPORTANT?

"Waste valorisation" is very important. When waste is not only collected but also valorised, it completes the waste management cycle in several important ways:

Resource Recovery:

Valorisation involves extracting valuable resources from waste materials. For example, organic waste can be converted into compost or biogas, and certain types of plastics can be recycled to produce new products. This process helps recover resources that would otherwise be lost if the waste were simply disposed of in landfills.

Reduction of Environmental Impact:

Valorisation can significantly reduce the environmental impact of waste. By recovering and reusing materials, less pressure is put on natural resources. Additionally, certain valorisation processes, such as waste-to-energy technologies, can help generate energy and reduce the need for fossil fuels, thereby decreasing greenhouse gas emissions.

Promotion of Circular Economy:

Valorisation aligns with the principles of a circular economy, where resources are used efficiently, and waste is minimized. By turning waste into valuable resources, the cycle of production, consumption, and disposal becomes more sustainable, reducing the reliance on finite resources.

Economic Opportunities:

Valorisation can create economic opportunities by generating new industries and markets for recycled materials and products. It can also lead to the development of innovative technologies and business models focused on turning waste into valuable commodities.

Waste Diversion from Landfills:

When waste is valorised, less material ends up in landfills. This helps alleviate the pressure on landfills, which can be environmentally harmful and have limited capacity. Diverting waste from landfills is crucial for reducing pollution and conserving space.

Community Engagement:

Waste valorisation often involves community participation in recycling programs. This engagement raises awareness about the importance of waste management, encourages responsible consumption, and fosters a sense of environmental stewardship among community members.

Legal and Regulatory Compliance:

Many regions have regulations that encourage or require waste valorisation as part of comprehensive waste management plans. By valorising waste, communities and businesses can comply with these regulations, avoiding potential legal consequences.

Innovation and Research:

The pursuit of waste valorisation often drives research and innovation in the field of sustainable materials management. This can lead to the development of new technologies and processes that further enhance the efficiency and effectiveness of waste valorisation.

Figure 24. *Footwear valorisation. Source: https://medium.com/@economicdonut/kicking-waste-to-the-curb-how-footwear-companies-can-embrace-circular-business-models-for-a-7b7d1c34da10*

4.3. STRATEGIES FOR THE VALORISATION OF WASTE IN THE FOOTWEAR MANUFACTURING INDUSTRY

By implementing valorisation strategies, the footwear manufacturing industry can move towards a more sustainable and circular approach, reducing waste and creating additional value from materials that would otherwise be discarded. This approach aligns with the broader goals of sustainable development and responsible resource management.

1.1. Material Recycling

Material recycling in the footwear industry is a sustainable practice that aims to reduce the environmental impact of footwear production and disposal. Several strategies and approaches are employed to recycle materials in the footwear industry, contributing to the principles of a circular economy.

Figure 2 https://www.centreforsmart.co.uk/projects/footwear-recycling

Material recycling in the footwear industry is a sustainable practice that aims to reduce the environmental impact of footwear production and disposal. Several strategies and approaches are employed to recycle materials in the footwear industry, contributing to the principles of a circular economy.

Figure 25*.Waste footwear in landfill. Source: https://www.centreforsmart.co.uk/projects/footwear-recycling*

Here are some key aspects of material recycling in the footwear industry:

Recycled Materials:

Upper Materials: Footwear uppers can be made from recycled materials such as recycled polyester, recycled nylon, or even recycled leather. Post-consumer recycled content, which comes from discarded products, and post-industrial recycled content, which comes from manufacturing waste, are both utilized.

Sole Materials: The soles of shoes can be made from recycled rubber or other recycled materials. Some companies use recycled rubber from old tires to create new shoe soles.

Recycling Production Waste:

Reducing Manufacturing Waste: Footwear manufacturers are increasingly focusing on minimizing waste during the production process. Any waste generated, such as excess materials or defective components, is often recycled or repurposed to reduce the overall environmental footprint.

Closed-Loop Systems:

Some footwear brands are exploring closed-loop systems, where old shoes are collected, broken down into their individual components, and then used to manufacture new shoes. This approach maximizes the reuse of materials and minimizes the need for new raw materials.

Biodegradable Materials:

In addition to recycling, some footwear brands are experimenting with the use of biodegradable materials for certain components of shoes. Biodegradable materials break down naturally over time, reducing the long-term environmental impact.

Recycling Programs:

Footwear companies may implement take-back or recycling programs where consumers can return old shoes. These programs allow the company to collect used footwear, disassemble it, and recycle the materials for use in new products.

Collaborations and Partnerships:

Collaboration between footwear companies and recycling facilities is essential. Partnering with recycling facilities and organizations can help streamline the collection and processing of materials, making the recycling chain more effective.

Innovations in Design and Manufacturing:

Innovative design and manufacturing techniques are being employed to create shoes that are easier to disassemble and recycle. Modular designs, where different components can be separated easily, facilitate the recycling process.

Consumer Education:

Educating consumers about the importance of recycling and making sustainable choices is crucial. Transparent communication about the materials used in footwear and the environmental benefits of recycling can influence consumer behaviour.

Material recycling in the footwear industry is part of a broader shift toward more sustainable and environmentally friendly practices. As consumer awareness and demand for sustainable products continue to grow, the footwear industry is likely to see further advancements in material recycling and eco-friendly manufacturing processes.

1.2. Material Upcycling

Upcycling footwear waste involves creatively repurposing or transforming discarded materials from the footwear industry into new, higher-value products. This sustainable approach helps reduce the environmental impact of the industry, minimizes waste, and often results in unique and innovative products.

Figure 3: https://www.therogueginger.com/2016/06/upcycle-shoes.html

Upcycling footwear waste involves creatively repurposing or transforming discarded materials from the footwear industry into new, higher-value products. This sustainable approach helps reduce the environmental impact of the industry, minimizes waste, and often results in unique and innovative products.

Figure 26. *Footwear upcycling*

Here are some ways in which footwear waste can be upcycled:

Textile Waste:

Old Shoes into New Designs: Discarded shoes or shoe components can be disassembled, and the materials, such as fabric, leather, or synthetic textiles, can be upcycled into new shoe designs. This could involve creating patchwork patterns, combining different textures, or incorporating the existing shoe elements into a fresh design.

Sole Upcycling:

Sole Reconstruction: Old shoe soles can be ground down and mixed with other materials to create new soles. Alternatively, they can be reshaped or layered to form unique, customized soles for different types of footwear.

Leather and Suede Scrap:

Patchwork and Accents: Leather and suede scraps from footwear production or old shoes can be upcycled into patchwork designs or used as decorative accents on new shoes. This can give the footwear a distinct and stylish appearance.

Shoelaces and Straps:

Accessory Upcycling: Unused or discarded shoelaces and straps can be upcycled into accessories such as bracelets, keychains, or even used as decorative elements on new shoes.

Inner Sole Materials:

Cushioning and Insoles: Materials from old shoe insoles can be repurposed into new cushioning materials or insoles for other footwear products. This process can contribute to comfort and support in new shoe designs.

Zipper and Buckle Reuse:

Closure Components: Zippers, buckles, and other closure components from old shoes can be salvaged and reused in new footwear designs, providing functional and aesthetic benefits.

Logo and Branding Elements:

Brand Logo Art: Brand logos or other distinctive elements from old shoes can be creatively integrated into new designs. This can add a nostalgic or brand-centric touch to upcycled footwear.

Mixed Material Creations:

Hybrid Footwear: Upcycling allows for the combination of different materials from various sources. For example, combining leather scraps with fabric or rubber elements from old shoes to create hybrid footwear that blends different textures and functionalities.

Collaborations with Artists:

Artistic Collaborations: Footwear brands can collaborate with artists or designers to turn waste materials into limited-edition, artistic footwear. This not only promotes sustainability but also adds a unique and exclusive aspect to the product.

Community Engagement:

Workshops and DIY Kits: Brands can engage with their community by organizing workshops or providing DIY upcycling kits. This encourages consumers to actively participate in transforming old footwear or related materials into new and personalized creations.

Upcycling footwear waste not only contributes to waste reduction but also fosters creativity and innovation within the industry. It aligns with the principles of sustainability, circular economy, and responsible consumption, offering environmentally conscious alternatives to traditional footwear production.

1.3. Energy Recovery

The footwear industry generates various waste materials during the manufacturing process, such as rubber scraps, leather offcuts, and other materials. While using these specific waste materials as a direct source of energy may pose challenges, there are alternative approaches that can be explored to maximize resource efficiency and minimize environmental impact:

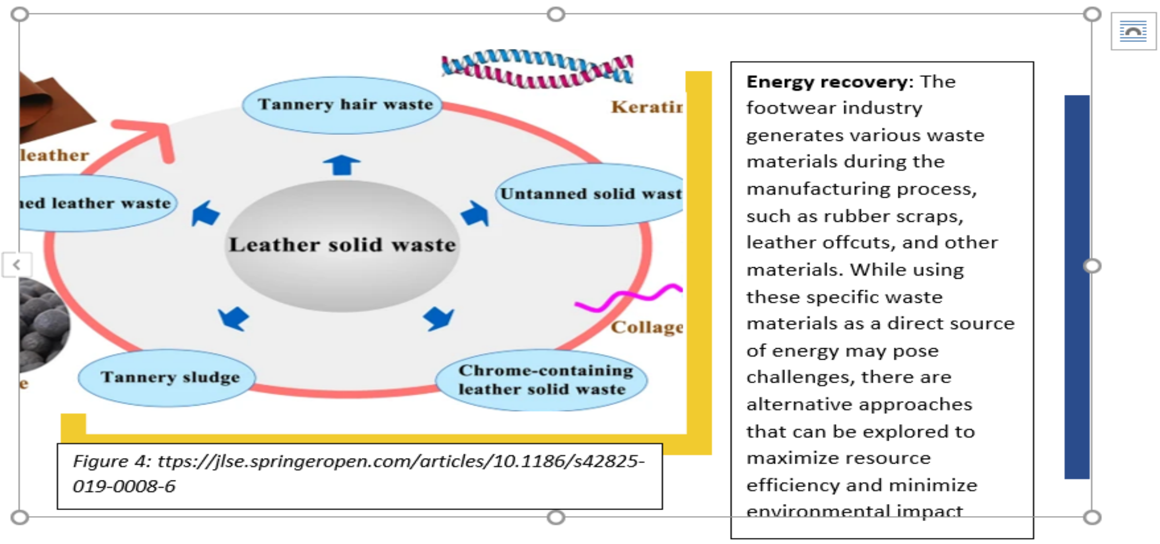


Figure 4: https://jlse.springeropen.com/articles/10.1186/s42825-019-0008-6

Figure 27. *Energy recovery. Source: https://jlse.springeropen.com/articles/10.1186/s42825-019-0008-6*

Recycling and Reuse:

Process: Instead of direct energy generation, focus on recycling and reusing waste materials within the industry. For example, rubber scraps and leather offcuts can be recycled to create new products, reducing the demand for virgin materials.

Waste-to-Energy (WtE) from Biomass:

Process: Explore the possibility of using organic waste from the footwear industry, such as leather scraps, in biomass energy production. Anaerobic digestion or composting can generate biogas or heat energy.

Advantages: Utilizes organic waste, reduces landfill reliance, and can contribute to the circular economy.

Considerations: The feasibility depends on the scale of waste generation and the local infrastructure for biomass energy production.

Pyrolysis for Rubber Waste:

Process: Rubber scraps from the footwear industry can undergo pyrolysis, a thermal decomposition process in the absence of oxygen, to produce oil, gas, and char.

Advantages: Converts rubber waste into valuable products, including liquid fuel.

Considerations: Economic viability and technology optimization need to be assessed. Emission control is important.

Incineration with Energy Recovery:

Process: Incinerate non-recyclable waste materials from the footwear industry to generate heat and electricity.

Advantages: Reduces waste volume, provides energy, and minimizes landfill use.

Considerations: Strict emission controls are necessary to mitigate environmental impacts.

Collaboration for Waste Streams:

Approach: Collaborate with other industries or organizations that can utilize specific waste streams from the footwear industry. For instance, rubber waste might find applications in road construction or soundproofing materials.

Circular Design and Closed-Loop Systems:

Approach: Implement circular design principles to minimize waste generation in the first place. Establish closed-loop systems where materials are reused or recycled within the footwear manufacturing process.

It's essential to conduct a thorough assessment of the waste composition, volumes, and available technologies before implementing any specific solution. Regulatory compliance, economic feasibility, and environmental considerations should guide the decision-making process. Additionally, collaboration with other industries, research institutions, and government agencies can contribute to the development and implementation of sustainable practices in the footwear industry.

1.4. Biodegradable Materials

The use of biodegradable materials in the manufacturing process of footwear is a sustainable practice that aims to reduce the environmental impact of the industry. Biodegradable materials break down naturally over time, returning to the environment without causing harm.

The use of **biodegradable materials** in the manufacturing process of footwear is a sustainable practice that aims to reduce the environmental impact of the industry. Biodegradable materials break down naturally over time, returning to the environment without causing harm.

Figure 5 https://wired.me/science/environment/biodegradable-plastic-shoes/

Figure 28. *Example of biodegradable materials. Source: https://wired.me/science/environment/biodegradable-plastic-shoes/*

Here are several ways in which biodegradable materials can be incorporated into the production of footwear:

Biodegradable Leather Alternatives:

Mushroom Leather (Mycelium): Mycelium, the root structure of mushrooms, can be grown into a leather-like material. This sustainable alternative to traditional leather is not only biodegradable but also versatile in terms of texture and appearance.

Piñatex (Pineapple Fiber): Piñatex is made from pineapple leaf fibers, a byproduct of the pineapple industry. It serves as a cruelty-free and biodegradable alternative to animal leather, offering a lightweight and durable material for shoe uppers.

Biodegradable Fabrics:

Organic Cotton: Organic cotton is grown without synthetic pesticides or fertilizers, making it a more environmentally friendly option. Cotton fibers are biodegradable and can be used in various parts of footwear, including uppers and linings.

Hemp: Hemp is a fast-growing plant that requires fewer pesticides and water compared to traditional crops. Hemp fibers can be used to create durable and biodegradable fabrics for different components of footwear.

Bamboo: Bamboo is a renewable resource that grows quickly and requires minimal intervention. Bamboo fibers can be used to create breathable and biodegradable textiles for shoe uppers.

Biodegradable Soles:

Natural Rubber: Natural rubber, derived from the sap of rubber trees, is biodegradable. It can be used for the production of shoe soles, providing flexibility and shock absorption while being environmentally friendly.

Biodegradable EVA (Ethylene Vinyl Acetate): Some companies are developing biodegradable alternatives to traditional EVA foam, commonly used in midsoles and insoles. These materials break down more readily in natural environments.

Biodegradable Insoles and Cushioning:

Cork: Cork is a natural and renewable material that can be used for insoles and as a component of cushioning systems. It is not only biodegradable but also provides comfort and moisture-wicking properties.

Recycled and Biodegradable Foam Alternatives: Some brands are exploring innovative foam materials made from biodegradable substances or recycled content for insoles and cushioning.

Biodegradable Adhesives:

Water-Based Glues: Traditional shoe manufacturing often involves the use of adhesives that may contain harmful solvents. Switching to water-based glues that are biodegradable and less toxic contributes to overall sustainability.

Packaging Materials:

Biodegradable Packaging: The use of biodegradable materials for shoe packaging, such as compostable bags or recycled paper, further reduces the environmental impact of the footwear industry.

End-of-Life Considerations:

Full Biodegradability: Designing footwear with end-of-life considerations, ensuring that the entire shoe, including all its components, can biodegrade in a responsible manner.

The incorporation of biodegradable materials in footwear manufacturing aligns with the principles of a circular economy and sustainable design. It helps mitigate the environmental impact of the industry by reducing reliance on non-renewable resources and minimizing waste. As consumer demand for eco-friendly products grows, the use of biodegradable materials in footwear is likely to become more widespread.

1.5. Collaboration with Suppliers

Working closely with material suppliers to source sustainable and recyclable materials is a crucial step for the footwear industry to reduce its environmental impact and embrace more sustainable practices.

Figure 6 https://www.adidas-group.com/en/sustainability/

Working closely with **material suppliers** to source sustainable and recyclable materials is a crucial step for the footwear industry to reduce its environmental impact and embrace more sustainable practices.

Figure 29. *Footwear sustainability*

Here's a guide on how footwear companies can collaborate with material suppliers to achieve this:

Set Sustainability Criteria:

Define clear sustainability criteria for materials. This may include recycled content, biodegradability, adherence to environmental certifications, and reduced environmental footprint in the production process.

Engage in Open Communication:

Foster open communication with material suppliers. Clearly communicate your sustainability goals and expectations. Encourage suppliers to share information about the environmental attributes of their materials.

Collaborate on Innovation:

Work collaboratively on the development of new and innovative materials. Encourage material suppliers to invest in research and development to create sustainable alternatives to traditional materials.

Visit Supplier Facilities:

Conduct on-site visits to supplier facilities to assess their sustainability practices. This helps ensure that the entire supply chain aligns with environmentally friendly principles.

Establish Long-Term Relationships:

Build long-term relationships with material suppliers. This encourages suppliers to invest in sustainable practices and make continuous improvements over time.

Demand Transparency:

Request transparency regarding the sourcing and production processes of materials. This includes information on raw material origins, manufacturing practices, and any certifications or standards the materials adhere to.

Prioritize Recyclability:

Prioritize materials that are easily recyclable or made from recycled content. This includes recycled polyester, recycled rubber, and other materials with a reduced environmental impact.

Consider Circular Economy Principles:

Embrace circular economy principles in material sourcing. Explore materials that can be easily disassembled, recycled, or upcycled at the end of their life cycle.

Encourage Certification:

Encourage suppliers to obtain and maintain certifications related to sustainability, such as Global Organic Textile Standard (GOTS), Bluesign, or Cradle to Cradle. Certifications provide assurance of environmental and social responsibility.

Support Local and Responsible Sourcing:

Prefer suppliers who engage in responsible sourcing practices. This may involve supporting local economies, ensuring fair labour practices, and minimizing the environmental impact of transportation.

Incorporate Sustainable Leather Alternatives:

Explore sustainable alternatives to traditional leather, such as mushroom leather (mycelium), Piñatex (pineapple leaf fibers), or other plant-based alternatives.

Implement Supplier Audits:

Conduct periodic supplier audits to assess their adherence to sustainability commitments. This can include evaluating their waste management practices, energy efficiency, and overall environmental stewardship.

Provide Incentives:

Offer incentives for suppliers who demonstrate commitment to sustainability, such as longer-term contracts, preferential treatment, or co-branding opportunities.

Educate Suppliers:

Provide educational resources to suppliers about the importance of sustainability in the footwear industry. Share information on market trends, consumer preferences, and the business advantages of adopting sustainable practices.

Celebrate Achievements:

Acknowledge and celebrate the achievements of material suppliers in adopting sustainable practices. This positive reinforcement encourages continuous improvement and commitment to sustainability.

By actively collaborating with material suppliers and integrating sustainable practices into the sourcing process, the footwear industry can play a significant role in promoting environmental responsibility and meeting the growing demand for sustainable products.

1.6. Research and Development

Investing in research and development (R&D) to find new and innovative ways to valorize waste materials in the footwear industry is a strategic approach that aligns with sustainability goals, resource efficiency, and the principles of a circular economy.

Figure 30*. Research and Development in Footwear. Source: https://sciled.eu*

Here are steps and considerations for footwear companies looking to invest in R&D for waste valorisation:

Identify Targeted Waste Streams:

Analyse the types of waste generated in the footwear industry, including manufacturing scraps, end-of-life products, and other byproducts. Identify specific waste streams that have the potential for valorisation.

Collaborate with Research Institutions:

Partner with research institutions, universities, and innovation centres that specialize in materials science, sustainable technologies, and circular economy practices. Collaborative efforts can leverage diverse expertise and resources.

Establish an R&D Team:

Build an internal R&D team or collaborate with external experts to focus on waste valorisation. This team should include professionals with expertise in materials engineering, chemistry, and sustainable design.

Define Clear Objectives:

Clearly define the objectives of the R&D efforts. Establish goals for waste reduction and identify materials that can be valued through new products, this can also involve the development of new processes or products.

Explore Valorisation Technologies:

Investigate emerging technologies for waste valorisation, such as advanced recycling methods, chemical processes, and bioconversion techniques. Explore how these technologies can be applied to transform footwear waste into valuable materials.

Experiment with Circular Design:

Implement circular design principles in the development of new footwear products. This includes designing for disassembly, using modular components, and incorporating recycled or upcycled materials.

Evaluate Sustainable Materials:

Explore alternative and sustainable materials that can be derived from waste streams. This may include developing materials from agricultural byproducts, recycled plastics, or other eco-friendly sources.

Consider 3D Printing and Additive Manufacturing:

Investigate the use of 3D printing and additive manufacturing technologies for creating footwear components from recycled materials. These technologies allow for precise and customized production.

Pilot Projects:

Conduct pilot projects to test and validate the feasibility of waste valorisation techniques. This may involve small-scale production runs or collaborations with suppliers and manufacturers.

Engage in Cross-Industry Collaboration:

Collaborate with other industries or sectors that are also working on waste valorisation. Cross-industry collaboration can bring fresh perspectives and shared resources.

Monitor Environmental Impact:

Consider the environmental impact of the valorisation processes. Aim for solutions that not only reduce waste but also minimize energy consumption, emissions, and other environmental footprints.

Assess Economic Viability:

Evaluate the economic viability of the developed valorisation processes. Sustainable solutions should be financially feasible for widespread adoption in the footwear industry.

Intellectual Property Protection:

If applicable, consider securing intellectual property rights for innovative valorisation processes or materials to protect investments and foster exclusivity.

Consumer Education and Marketing:

Communicate the sustainability benefits of products derived from valorised waste materials to consumers. Educate the market about the positive environmental impact and encourage responsible purchasing.

Investing in R&D for waste valorisation in the footwear industry not only contributes to environmental sustainability but also positions companies as leaders in innovation. By turning waste into valuable resources, footwear companies can positively impact the industry's ecological footprint and meet the growing demand for sustainable products.

1.7. Community Engagement

Engaging with local communities to identify potential uses for waste materials in community projects is a meaningful way for the footwear industry to contribute to sustainability and strengthen community ties.

Figure 8: https://www.cseindia.org/workshop-on-managing-solid-waste-10829

Engaging with local communities to identify potential uses for waste materials in community projects is a meaningful way for the footwear industry to contribute to sustainability and strengthen community ties.

***Figure 31**. Engaging with local communities.*
Source: https://www.cseindia.org/workshop-on-managing-solid-waste-10829

Here's a guide on how footwear companies can collaborate with local communities for waste utilization in community projects:

Community Outreach and Collaboration:
Establish partnerships with local community organizations, non-profits, and grassroots initiatives. Engage in open and transparent communication to understand community needs and preferences.

Conduct Needs Assessments:
Work closely with community members to conduct needs assessments. Identify areas where waste materials from the footwear industry could be repurposed to benefit the community, such as in construction, art projects, or local initiatives.

Community Workshops and Education:
Organize workshops and educational sessions to inform community members about the types of waste materials generated by the footwear industry and potential uses for these materials. This fosters awareness and creativity within the community.

Identify Local Artisans and Crafts persons:

Identify local artisans or crafts persons who can collaborate on community projects. They may have valuable insights into creative ways to utilize waste materials for artistic or functional purposes.

Co-Design Projects with the Community:
Embrace a participatory design approach by involving community members in the design process. Co-create projects that meet both the needs of the community and the goals of waste reduction.

Community Garden Projects:
Explore the use of waste materials for community garden projects. For example, recycled rubber could be used for pathways, discarded shoe soles for planters, or old shoeboxes for seed starting containers.

Infrastructure and Construction Projects:
Collaborate on local infrastructure projects that can utilize waste materials. For instance, recycled materials could be used in community playgrounds, pathways, or public seating areas.

Educational Initiatives:
Support educational initiatives within the community that focus on sustainable practices. Offer resources and expertise to schools or community centres to integrate waste utilization projects into educational programs.

Public Art Installations:
Facilitate public art installations made from waste materials. This not only enhances the aesthetic appeal of the community but also serves as a visible reminder of the importance of waste reduction.

Footwear Donation Programs:
Develop programs to donate excess or unused footwear to community members in need. These addresses both waste reduction and social responsibility, contributing to the well-being of the community.

Skills Development Programs:
Establish skill development programs that teach community members how to repurpose waste materials into useful items. This empowers individuals with new skills and fosters a sense of ownership and pride in community projects.

Local Economic Development:
Explore opportunities for local economic development by integrating waste materials into small-scale business initiatives. This could include the production of artisanal footwear or other marketable products.

Community Events and Festivals:
Sponsor or participate in community events and festivals that showcase projects utilizing waste materials. This creates a sense of celebration and community pride in sustainable practices.

Regular Feedback and Collaboration:
Establish mechanisms for regular feedback and collaboration. Actively seek input from community members on the effectiveness of projects and identify opportunities for improvement or expansion.

Document and Share Success Stories:
Document the success stories and positive impacts of community projects. Share these stories through various channels, including social media, to inspire other communities and industries to adopt similar initiatives.

By actively engaging with local communities and involving them in waste utilization projects, the footwear industry can contribute to environmental sustainability, social responsibility, and community resilience. This collaborative approach not only benefits the community but also creates a positive and lasting impact on the industry's image and relationships with its stakeholders.

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