

## ECO-FRIENDLY INNOVATIONS IN CONTEMPORARY ADORNMENT AND FINE JEWELRY DESIGN FOR A SUSTAINABLE FUTURE

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Această cercetare explorează inovațiile în designul sustenabil al podoabelor vestimentare, evidențiind utilizarea materialelor eco-friendly, cum ar fi fibrele naturale, pielea vegană, metalele reciclate și rășinile ecologice. Progresele în biotehnologie au condus la dezvoltarea fibrelor vegetale modificate genetic, biodegradabile și durabile, iar piețele emergente pentru pielea Piñatex și alte alternative regenerabile reflectă o tendință globală de reorientare către sustenabilitate. Designerii contemporani, precum Alba Prieto, adoptă tehnici de producție digitale, inclusiv imprimarea 3D, pentru a reduce risipa materialelor, creând bijuterii din metale reciclate și plase de pescuit recuperate. Această cercetare subliniază importanța integrării resurselor regenerabile în designul podoabelor, punând accent pe estetica și funcționalitatea sustenabilă. Prin implementarea acestor principii, industria modei se transformă, oferind soluții inovative care nu doar minimizează impactul ecologic, ci și îmbogățesc experiența estetică a consumatorului.

**Cuvinte-cheie:** *design sustenabil, materiale eco-friendly, designul podoabelor vestimentare, bijuterie contemporană, imprimare 3D, sustenabilitate, resurse regenerabile.*

This research explores innovations in sustainable fashion accessory design, highlighting the use of eco-friendly materials such as natural fibers, vegan leather, recycled metals, and ecological resins. Advances in biotechnology have led to the development of genetically modified plant fibers that are biodegradable and durable, while emerging markets for leather Piñatex and other renewable alternatives reflect a global trend toward sustainability. Contemporary designers, such as Alba Prieto, adopt digital production techniques, including 3D printing, to reduce material waste, creating jewelry from recycled metals and recovered fishing nets. This research emphasizes the importance of integrating renewable resources in accessory design, focusing on sustainable aesthetics and functionality. By implementing these principles, the fashion industry is transforming, offering innovative solutions that not only minimize ecological impact but also enrich the consumer's aesthetic experience.

**Keywords:** *sustainable design, eco-friendly materials, design of contemporary jewelry, contemporary jewelry, 3D printing, sustainability, renewable resources.*

*"Jewelry is a way of carrying art with you."  
/Joyce Carol Oates/*

### Introduction

In recent decades, the concept of sustainability has become an essential element across various industries, including fashion and fashion accessory design. Current trends in fashion clearly reflect a shift towards using eco-friendly materials that are recyclable or organic. Contemporary designers are exploring innovative solutions, using natural fibers, vegan leather, and recycled metals to create jewelry

and fashion accessories that not only enhance aesthetic appeal but also contribute to environmental protection.

Scientific innovation in this field lies in the development of new, durable, and environmentally friendly materials capable of replacing conventional materials used in fashion accessories. Significant progress has been made in biotechnology and materials development, such as genetically modified plant fibers, which offer increased durability and biodegradability. Additionally, research into vegan leathers has led to the creation of alternatives based on renewable resources, such as pineapple leather (Piñatex), mushroom leather, or apple leather.

In current practices, designers are also exploring new digital production techniques. 3D printing of jewelry has become an efficient way to reduce material waste. This process allows the creation of complex shapes from recycled metals or biodegradable resins with high precision, minimizing waste from conventional cutting or molding processes. An example is designer Alba Prieto, who uses 3D printing to create jewelry from recycled materials, including fishing nets collected from beaches. Through this technique, not only does she give new life to a recovered polluting material, but she also offers avant-garde, minimalist pieces adapted to contemporary trends.

### **Scientific context and previous studies**

Over time, various studies have explored the environmental impact of the fashion industry<sup>1</sup>, highlighting the need for major changes. Fashion accessories have often been considered aesthetic items, but recent studies show that these products can have a significant ecological impact, particularly through the use of synthetic materials that do not degrade easily and contribute to environmental pollution. A 2017 report by *Pulse of the Fashion Industry* emphasized that the fashion industry is responsible for 8-10% of global carbon emissions and consumes significant amounts of water and energy resources. Although fashion accessories are considered a smaller segment of the industry, they play an important role in this ecosystem, as production processes often involve precious minerals and metals obtained through unsustainable methods. Metal production and recycling require high energy consumption and can generate waste and emissions. Global pressure for sustainability has led the fashion industry to adopt more eco-friendly practices, including the use of recycled materials, natural fibers, and innovative technologies to reduce ecological impact.

### **Design aspects of eco-friendly fashion accessories**

To analyze the implementation of sustainability principles in the design of eco-friendly accessories, it is useful to examine the key aspects of this field. Table 1 illustrates the classification of these aspects, including innovative materials, efficient production processes, and aesthetic and durability considerations, providing a clear perspective on how designers are adapting technologies and eco-friendly materials to meet current challenges.

**Table 1. SUSTAINABLE PRACTICES IN ECO-FRIENDLY FASHION ACCESSORY DESIGN**

CATEGORY	DESIGN ASPECTS	EXAMPLES
MATERIAL	Use of recycled materials (Figure 1).	Jewelry made from metals recovered from electronic waste.
	Use of natural and organic fibers.	Hemp necklaces, organic bamboo bracelets.
	ECO (vegan) leather from renewable sources (Meyer).	Pineapple leather (Pinatex), mushroom leather.
PRODUCTIO N PROCESSES	3D printing for jewelry (Figure 2a, 2b).	Jewelry created from recycled fishing nets, avant-garde design.
	Energy-efficient recycling process.	Use of energy-efficient recycling technologies.
	Minimal processing of materials to reduce waste.	Jewelry cast from recycled materials with complex shapes, minimizing waste.
AESTHETIC DESIGN	Innovation in shapes and textures.	Jewelry with natural flowers preserved in resin, unique textures from vegan leather.
	Adapting design to eco-friendly materials.	Necklaces and earrings made from natural fibers dyed with natural dyes (Figure 3).
DURABILITY AND FUNCTIONA LITY	Designing for longevity and reuse.	Modular jewelry that can be adjusted or repaired.
	Use of design techniques that ensure the durability of materials.	Design that prevents rapid wear and allows for easy recycling.



Figure 1. Eco-friendly jewelry. Photo from Daniel Jackson, Vogue, 2019.



Figure 2. Eco-friendly jewelry, 3D printing, 2022. Design Sarah Angold. 2a. Elastic bracelet made of acrylic with a brass detail. 2b. Necklace made of acrylic and brass with a gold clasp.



Figure 3. Pendants made from dried flowers, 2020. Design Carabetchi Ana, Iamboglo Alina.

Contemporary designers are increasingly concerned with the environmental impact of the materials and processes used in creating accessories. They combine aesthetics with sustainable functionality, producing items that impress both with their innovative design and commitment to environmental protection.

A relevant example is the use of *vegan leather* from renewable sources, such as Piñatex, a biodegradable alternative to traditional leather. Made from cellulose fibers extracted from pineapple leaves<sup>3</sup>, PLA, and petroleum-based resin, it was developed by Carmen Hijosa and first introduced at the Royal College of Art in London (Duangsuwan, 3-5). Piñatex has been adopted by designers for creating bracelets and watch straps, offering an alternative to animal leather, with a sophisticated and natural appearance, highlighted by unique textures that vary depending on processing. In 2023, experimental research is being conducted at the Technical University of Moldova on the use of vegan leather based on gelatin and/or agar-agar within the Faculty of Design, in the discipline of Innovations through Biodesign, under the guidance of Florea-Burduja Elena, Raru Aliona, and their team. This research contributes to the development of innovative solutions in the field of sustainable accessories (Figure 4a, 4b).



Figure 4a. Vegan leather based on gelatin and/or agar-agar. UTM. European Researchers' Night, 27.09.2024. Photo from the personal archive of Matcan-Lisenco I.



Figure 4b. Vegan leather based on gelatin and/or agar-agar. UTM. European Researchers' Night, 27.09.2024. Photo from the personal archive of Matcan-Lisenco I.

Additionally, *recycled materials* such as glass, plastic, rubber, and, not least, recycled textiles have become an essential component in eco-friendly accessories. A notable example is jewelry collections made from precious metals recovered from electronic waste. Metals such as gold and silver, which are extracted from used electronic devices, are repurposed to create necklaces, rings, or earrings, retaining their value and brilliance, but with a much lower environmental impact.

Recently, there has been increased interest in *natural fibers*, such as organic cotton, hemp, and linen, which have also found interesting applications in accessory design. Necklaces and bracelets made from hemp yarn dyed with natural colorants provide an aesthetic and durable alternative to products made from synthetic materials. Additionally, these fibers are biodegradable and do not leave harmful traces in the environment after the products reach the end of their life cycle<sup>5</sup>. These materials contribute to reducing pollution (Klerk 18-23), conserving natural resources, and minimizing waste, representing a significant part of the global trend towards sustainability in accessory design.

To further elaborate on the aspects related to the use of vegan fibers in eco-friendly accessory design, additional information on the main types of fibers and their characteristics is necessary (Table 2).

Table 2. NATURAL AND VEGAN FIBERS IN ECO-FRIENDLY ACCESSORY DESIGN

CATEGORY	TYPE OF FIBERS	DESCRIPTION	CHARACTERISTICS/ ADVANTAGES	DISADVANTAGES
NATURAL FIBERS	Bamboo	Grown without pesticides or synthetic fertilizers.	Light, durable, water-resistant, does not degrade quickly, and is a good renewable resource.	It requires special processing to become sufficiently fine and aesthetically pleasing. It may be less versatile in the design of complex jewelry.
	Linen	Grown without chemical fertilizers, it is valued for its fine-quality fibers.	Cool, sturdy, durable, dries quickly, eco-friendly, and completely biodegradable.	It can be rigid and difficult to shape, limiting the design of complex jewelry. If not treated properly, it may have an unsuitable (rough) appearance for fine jewelry.

Table continued

NATURAL AND VEGAN FIBERS IN ECO-FRIENDLY ACCESSORY DESIGN

CATEGORY	TYPE OF FIBERS	DESCRIPTION	CHARACTERISTICS/ADVANTAGES	DISADVANTAGES
	<b>Hemp</b>	Cultivated with minimal water usage and free of pesticides, it offers an environmentally friendly option to synthetic fibers.	Grows quickly, strong, durable, biodegradable, and sustainable, with a rustic texture.	The texture of the fibers is rough, which limits their use in finer adornments. Strict cultivation regulations in some countries affect the availability of hemp.
	<b>Wool</b>	Obtained from animals raised in humane conditions.	Warm, durable, biodegradable, water-resistant, and easily recyclable.	It can cause allergies, and if not treated correctly, it becomes less durable and prone to degradation.
	<b>Hempcrete (hemp and limestone)</b>	Combines hemp fibers with limestone, providing a durable and eco-friendly material.	Lightweight, durable, with thermal insulation properties, which can add extra value in certain innovative applications.	It is more rigid and bulky, suitable for large decorative accessories. The manufacturing process is more complicated and costly, with limited applicability in fine jewelry design.
<b>VEGAN FIBERS</b>	<b>Pineapple leather (Pinatex)</b>	Made from pineapple leaves, an agricultural byproduct.	Durable, easy to process, texture similar to natural leather, long-lasting.	The price may be higher than that of conventional leathers due to the more complex production process.
	<b>Mushroom leather (Mycelium)</b>	Obtained from mycelium, the root structure of mushrooms (Jones 9-11).	Biodegradable, flexible, similar to natural leather (Su), easy to customize.	Wear resistance and appearance may not always be comparable to traditional leather.
	<b>Apple leather</b>	A vegan material based on biomass, composed of industrial apple peel waste (31%) – dried, ground, and mixed with polyurethane. USDA certified <sup>9,10</sup> .	Water-resistant, appearance similar to vegan leather (traditional), natural, durable, and eco-friendly. Has a luxurious look and is bio degradable.	It has limited resistance to wear and damage compared to animal leather, and the production process is costly, leading to higher prices for final products.
	<b>Algae leather</b>	Produced from seaweed, typically blended with other materials.	Lightweight, durable, renewable, biodegradable, distinctive texture, innovative appearance.	It is less durable and harder to find, and the price may be higher due to limited availability.
	<b>Cotton leather</b>	Made from organic cotton, serving as an eco-friendly alternative to traditional leather.	Soft, flexible, easy to process and dye, it is a renewable and biodegradable resource.	A limited lifespan, lower wear resistance, high manufacturing costs, poor water resistance, and it requires special care to maintain its appearance.

The information presented above highlights the diversity and versatility of vegan and natural materials used in accessory design, emphasizing their contribution to sustainable and innovative design practices. These fibers not only reduce ecological impact but also bring a unique aesthetic and superior functionality to the creation of jewelry and fashion accessories.

It is important to mention sustainable shells and pearls, which are also natural and renewable materials, often obtained through eco-friendly methods. They offer a variety of textures and color palettes, opening up numerous creative possibilities, while natural pearls are biodegradable and symbolize luxury. However, irresponsible extraction can affect coral reefs, and natural pearls are expensive.

Another innovative design aspect is the use of *renewable resources* in creating jewelry. For example, designer Marcin Rusak uses *preserved natural flowers* in resin to create unique pieces, such as pendants and earrings. This type of design combines the natural beauty of flowers with the durability of eco-friendly resins, offering a product that highlights the direct connection between nature and fashion.

Other examples of renewable resources used in contemporary accessory design include: recycled wood, volcanic stone, tree bark (birch, coconut, linden, etc.), and banana fiber.

*Recycled wood* is a valuable resource in the production of contemporary jewelry due to its durability, eco-friendly nature, and natural aesthetic. By reusing this material, designers create pieces that pay homage to nature while preserving its raw and authentic look. The use of recycled wood in jewelry involves a series of modern and traditional technologies, allowing it to be shaped into various detailed forms.

CNC (Computer Numerical Control) cutting and carving offer exceptional precision in crafting rings, pendants, and bracelets, enabling designers to create intricate designs from recycled wood. Other technologies, such as *laminated wood*, allow for the combination of different wood types, giving the jewelry a unique design and increased strength. Additionally, *pressing and compressing* processes make the wood denser, suitable for everyday wear pieces. To enhance durability and aesthetic appeal, recycled wood surfaces are often treated with natural oils, such as linseed or wax, which give it shine and protection against moisture. Depending on its origin, recycled wood can be categorized in various ways. *Wood recovered from construction*, demolition, or old furniture is processed into raw material for unique jewelry. Driftwood, brought by the sea, has unique textures due to exposure to the elements, making it ideal for rustic and organic jewelry. Moreover, recycled wood from used products, such as furniture or household items, is reused to create rings or bracelets with original designs.

Contemporary designers use various methods to implement recycled wood in jewelry. *Inlaying wood* with precious metals or semi-precious stones creates a striking aesthetic contrast, combining the natural beauty of wood with the refinement of metals. Another popular method is the combination of materials, with wood often being paired with silver, gold, or leather, resulting in complex and elegant pieces. At the same time, many pieces of recycled wood jewelry are personalized, with designers using engraving techniques to offer uniqueness to each piece. Recycled wood brings aesthetic and symbolic value to contemporary jewelry, appreciated for its durability and respect for nature. At international exhibitions, pieces such as the "Timber Revival" bracelet by Fernando Rodriguez, the "Forest Whisper" pendant by Julia Langenberg, and the "Bark Essence" earrings by Maria Trifonova have showcased the innovation and creativity of

designers in using recycled wood. These pieces highlight the importance of sustainability and the natural beauty of the material.

*Volcanic stone* (solidified lava) is a popular material in contemporary jewelry due to its unique appearance and physical characteristics (lightweight, porous, rough texture), which bring a natural and organic aesthetic to jewelry. As a renewable and eco-friendly material, it is valued for both its symbolic meaning and versatility. Volcanic stone is processed through manual cutting and polishing to obtain various forms in jewelry, maintaining its distinctive texture. CNC technology allows the addition of fine details, and surface treatments protect the material's porosity. Classified into three main types - black, reddish, and gray - each variety has specific uses. Volcanic stone is frequently used in necklaces, bracelets, and as essential oil diffusers, often combined with precious metals for an attractive aesthetic contrast.

Tree bark, especially *coconut bark*, is a lightweight, durable, and biodegradable material that reduces resource waste. It is used in contemporary jewelry for its natural appearance and tropical aesthetic, unique look, and renewable nature. However, its hard and irregular texture can limit design possibilities, and the finishing process is challenging to achieve a smooth and even surface. Processing technologies include manual cutting and shaping, allowing for the creation of unique pieces, sanding to achieve a smooth texture while preserving its natural characteristics, and applying protective treatments with eco-friendly lacquers or oils to improve durability. Implementation methods in jewelry include creating items that reflect a natural style and combining bark with metals for interesting visual effects, as well as eco-friendly jewelry featured in collections that emphasize sustainability. Representative examples of the use of coconut bark in exhibitions include the "Eco Art" exhibition in Berlin, 2023, where coconut bark jewelry was showcased, and the "Sustainable Fashion Showcase" in Milan, where coconut bark was integrated into various pieces, highlighting ecological trends. Thus, tree bark proves to be a versatile and inspiring material in jewelry design, bringing a contemporary and sustainable vibe.

*Banana fiber*, or "vegan silk," is an increasingly popular material in contemporary jewelry due to its ecological and aesthetic properties. Obtained from banana stems, this fiber is renewable and biodegradable. The processing involves harvesting, braiding, and finishing the fiber, which can be treated with eco-friendly oils to enhance its durability. Banana fiber is classified into natural, dyed, and treated types, each with distinct characteristics. Compared to other natural fibers, banana fiber stands out for its fine texture and natural sheen. Opportunities for use are promising, given the growing demand for eco-friendly products and innovations in design. It can be implemented in jewelry such as rings, earrings, and pendants, frequently featured in exhibitions like "Eco Chic" in Paris and "Sustainable Fashion Week" in London. Banana fiber proves to be a versatile and refined material in jewelry design, contributing to contemporary ecological trends.

Integrating renewable resources into jewelry design not only promotes sustainability but also stimulates creativity, offering designers the opportunity to explore new forms and textures. This fusion of aesthetics and ecological responsibility is redefining industry standards and inspiring consumers to appreciate the beauty of nature, transformed into unique wearable art pieces.

**Discussions** on the ecological impact of traditional materials highlight the

negative effects of synthetic materials on the environment. It is important to explore how and why these materials contribute to pollution and to what extent the use of eco-friendly materials can mitigate this impact. Moreover, market adoption and consumer demand for eco-friendly accessories is a critical aspect. Ecological awareness influences purchasing choices, and effective strategies can encourage the widespread adoption of these products. Discussions on innovative technologies in eco-friendly design could cover emerging technologies, such as 3D printing and the use of recycled materials, and how they affect the design and production of fashion accessories. Additionally, it is essential to identify the challenges and obstacles that hinder the widespread adoption of eco-friendly materials, including high costs, limited material availability, and technical limitations. Finally, it is necessary to analyze the role of designers in promoting sustainable materials and how innovations in design contribute to developing a more ecologically responsible sector.

To continue this study, it is necessary to explore several essential directions that can contribute to advancing sustainable design in the fashion and accessory industries. First, it is important to assess the long-term impact of using eco-friendly materials, both on the environment and the fashion industry. Such research should include detailed analyses of product life cycles. Additionally, a relevant direction is comparing the performance of eco-friendly materials with traditional ones, investigating aspects such as durability, strength, aesthetics, and comfort.

Another important aspect is the economic impact of sustainable materials, where studies could address production costs, sale prices, and their long-term efficiency. Moreover, consumer acceptance plays a crucial role, requiring research into their perception of eco-friendly accessories and identifying factors that influence purchasing decisions.

Technological innovations represent another promising field, where it is essential to investigate the development of sustainable production technologies, such as 3D printing and advanced recycling techniques. Furthermore, the integration of renewable materials into accessory design should be explored, identifying new sources and innovative production methods. By addressing these directions, the study can significantly contribute to the development of the sustainable production industry, promoting more responsible and innovative fashion.

### **Conclusion**

Sustainability and eco-friendly materials in accessory design represent a promising direction in the fashion industry (Omoloso). Contemporary designers play a crucial role in transforming this industry by exploring and adopting new materials and production techniques that respect the environment. By using materials such as vegan leather, natural fibers, recycled metals, and renewable resources, eco-friendly accessory design not only contributes to reducing the ecological impact but also offers new aesthetic and technological possibilities. Thus, fashion accessories become a perfect combination of art, technology, and sustainability, offering future solutions for responsible fashion.

## Note

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<sup>1</sup>Vezi: ILO. *Textiles, clothing, leather and footwear sector*. Disponibil: <https://www.ilo.org/industries-and-sectors/textiles-clothing-leather-and-footwear-sector> [Last accessed: 05.09.2024].

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<sup>3</sup>*Leather alternative Pinatex is made from pineapple leaves*. Dezeen. Disponibil: <https://www.dezeen.com/2016/06/09/pinatex-ananas-anam-vegan-leather-alternative-ethical-recycled-pineapple-leaves-sustainable-materials-design-camper/> [Last accessed: 3.12.2024].

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