Sustainability of the European textile industry

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Abstract. The objective of this article is to study sustainability of the European textile industry. The descriptive-analytical method is used to fulfill the aim - the theoretical aspects of the researched scientific field are investigated on the basis of a current literature survey. The collected information is summarized and analyzed using a systematic approach; an analytical approach; a study of the works of authors in the field; a comparative analysis; an observational method; and the determination of relative shares. The textile industry in the context of the circular economy and the Union’s policies should lead to improvements in the environmental performance of textile raw materials and materials, production, consumption, textile waste management, as well as their reduction, recycling, processing and environmental impact calculation. The sustainability of the textile industry can also be realized through the development and implementation of digitalization. Sustainability development of textile industry includes the three dimensions of sustainability: social, ecological and economic, which can be implemented in the context of the circular economy, digitalization and Sustainable Development Goals for the textile industry, in line with Europe 2030 policies.

Keywords: sustainability, circular economy, digitalization, textile sector, European textile industry.

1 Introduction

Sustainable living is becoming more and more relevant nowadays as the impact of production and waste becomes more and more obvious. The goal of sustainable development is to create cycles of behaviour with the greatest long-term benefits for the largest number of people [1]. Sustainable has been at the center of the economic research of the last four decades and the core strategy of European Union. The term refers to three main components - economic component, which is associated with growth, the environmental component that refers to the preservation of the ecosystem, and the social component. The sustainable green growth strategy pursued at European level is based on the strategic choice of an economic growth model that takes into account specific environmental aspects [2].

The sustainability of the textile industry is presented as a way to minimize environmental and social crises in order to preserve resources for future generations. In the context of sustainability, there has been a mobilisation of some sectors (including the textile sector) for the implementation of the Sustainable Development Goals for the textile industry, in line with Europe 2030 policies.
2 Results and discussion

2.1 Sustainability of the European textile industry in the context of the circular economy

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The circular economy is a growing topic, especially in the European Union, which promotes the responsible and circular use of resources that can contribute to sustainable development of industry (including the textile industry). It is a general concept, including different meanings, it becomes defined action plans supported by specific indicators.

Based on key literature, the authors define the circular economy as a regenerative system in which resource input and waste, emissions and energy leakage are minimized by slowing, closing and narrowing material and energy chains. This can be achieved through sustainable design, maintenance, repair, reuse, rework, renovation and recycling.

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The valuation of materials within a closed system is the basis of a circular economy concept. Through it, natural resources can be used while reducing pollution or avoiding resource constraints, sustaining economic growth. The circular economy is becoming a way to achieve sustainability. The authors also succeed in defining the main barriers to the implementation of the concept: technological, political and regulatory, financial and economic, governance, performance indicators, consumer and social.

The circular economy is recognised as a powerful integrative framework designed to address societal problems of environmental pollution and resource depletion. Its adoption is rapidly reforming production, manufacturing, consumption and recycling in different segments of the economy.

Prevailing definitions of sustainability are evolving with growing awareness of the delicate interaction between the environment, human health and well-being, and the economy. Product sustainability is now seen in the context of creating a circular economy—a sustainable system that eliminates waste, reduces pollution and ensures resource continuity.

Key sectors for building a circular economy in Europe include the textile industry, requiring changes at different stages of the chain—from design through production to use by end users.

The goals of the new circular economy are related to restructuring and reorienting the linear economy towards more sustainable approaches. This, according to the authors, can be focused on four main parts of the apparel system wheel, as follows: (1) materials, (2) production, (3) use, and (4) post-use. In all parts, mass innovation is paramount, given that the textile industry is an old industry whose processes are difficult to change, which can be expressed in (1) phasing out substances of concern and releasing microparticles, (2) increasing the use of clothing, (3) improving recycling, and (4) using resources efficiently and switching to renewable raw materials.

Fig. 1

![Circular Economy Diagram](image-url)
Application of circular fashion needs a system perspective where all the designers, manufacturers, suppliers, retailers and consumers are involved and committed with a positive shift in mind set [16]. To create a greener and more competitive textile sector, the EU Strategy for Sustainable and Circular Textiles published on 30.03.22 targets the production and consumption of textiles while recognizing the importance of the textile sector. It fulfills commitments under the European Green Deal, the new circular economy action plan and the industrial strategy.

The strategy aims to create a greener, more competitive sector that is more resistant to global shocks. The Commission’s 2030 Vision for Textiles is that:

- all textile products placed on the EU market are durable, repairable and recyclable, to a great extent made of recycled fibres, free of hazardous substances, produced in respect of social rights and the environment;
- “fast fashion” is out of fashion” and consumers benefit longer from high quality affordable textiles;
- profitable reuse and repair services widely available;
- the textiles sector is competitive, resilient and innovative with producers taking responsibility for their products along the value chain with sufficient capacities for recycling and minimal incineration and landfilling [9].

The sustainability of the textile industry is related to the circular economy. Through the circular economy and its relationship with the textile industry, policies are created by alliances, governments, sectors and companies to lead to the improvement of the environmental performance of textile raw materials and materials, production, consumption, textile waste generation, as well as their reduction, recycling, reprocessing and calculation of the effect on the environment and people, which can achieve sustainability. Scarce resources and climate change require society to transition to a carbon-neutral, pollutant-free and environmentally sustainable economy.

2.2. Sustainability and digitalization of the European textile industry

Digitalization will change the global and European textile industry in the coming decades. Digitalization is defined as the integration of digital technologies into everyday life. Digitalization is automating processes, measuring aspects of business that were previously...
Digitalization is the process of converting analogue processes and physical objects into digital format by which certain processes can be manipulated through digital media (as computers or smartphones), usually via an internet connection. The origin of the word digitalization is the Latin word digitus, meaning finger. The English word digit means a digit in computer science.

The global textile industry is expected to grow by 4% annually between 2022 and 2030. Digitalization plays an important role in the sustainable development of the textile industry, as the entire textile production process can be tracked—from design, through sourcing of materials and all stages of production, to delivery of the product to the consumer and disposal of the end-of-life product. The application of artificial intelligence (AI), 3D printing, Smart clothing, Machine-to-Machine (M2M) communication, Internet of Things (IoT), Digital Product Passport (DPP)...

The application of artificial intelligence (AI)...

- Al application to detect visual defects and wrinkles in the fabric;
- machine learning to identify previously hidden patterns from raw data to help businesses improve efficiency and maintenance;
- machine learning to optimize inventory and supply chain management;
- AI-based yarn fibres for new designs and materials;
- AI algorithms to tracking of consumer behavior.

3D printing has changed and influenced various fields such as engineering, manufacturing and the use of textile materials. 3D printing technology provides the textile industry with the opportunity to experiment with innovative textile materials. This technology can also become a decisive factor in the sustainable development of the textile industry. 3D printers can make more efficient use of recyclable textile materials in production, helping to achieve textile waste-free production. However, research in the 3D printing of textile industry has lagged behind other areas of applying...

The integration of electronics in textile manufacturing can be divided into three classes, such as smart clothing, wearable electronics and wearable computers (fig. 3).

Fig. 3. Area of textiles embedded with electronic devices.
**Smart clothing** combines the latest technology with traditional textile design and technology. The integration of the latest technology in smart textiles is making inroads in many industrial fields (medicine, fashion, sports and fitness, military and security). The development of new technologies and industrial digital modernization are encouraging the entire textile industry to carry out rapid technological transformation of the textile sector.

The idea of developing smart clothing and integrating it into our daily lives requires a high demand for smart products that can be used in different areas of life—medicine, implants, elderly care, work and sports, workwear, military applications, aerospace, etc.

**Machie-to-Machine (M2M) communication** is networked machines that communicate with each other without human intervention. It is based on the use of sensors that continuously transmit their data (in digital form) to a central system and from there to another machine. The M2M system can be used to control machinery and equipment, collect data, signal faults, communicate the need for maintenance, check the amount of material being processed. Such machines are called intelligent and are being developed by IT companies and could certainly be used in the textile industry [18].

The implementation of the Internet of Things (IoT) in the textile industry in various scales of applications is relevant today. The concept of IoT deployment is growing due to the interconnectivity of devices, vehicles and applications. In IoT deployment, it is necessary to connect many software and devices coupled with sensors of different classes to optimize processes control activities using IoT-enabled computer. Some of the IoT programs are based on Java, C, C++, python etc.

The desired characteristics of an IoT program are scalability, concurrency, coordination, heterogeneity, fault tolerance, small footprint and sensitivity. More research is to be conducted on the application and deployment (Fig. 4.) of IoT programs in the textile industry [21].

**Fig. 4. Implementation of IoT on a Textile weaving machine**

The EU Digital Product Passport (DPP) is a mandatory electronic register that will be required in full by 2030, developed in line with EU Green Deal legislation in relation to the EU Sustainable Textiles Strategy. The aim of the DPP is to enable “clear, structured and accessible information on the environmental sustainability performance of textile products. The basic data requirements for textile products to be included in the DPP will be defined in EU legislation by the end of 2023. The legislative period for the Digital Textile Passport, 050 (2023)
2.3. Sustainable development of the European textile industry

Sustainability development meets the needs of the society in present time without compromising the ability of future generations to meet their own needs in harmony with the natural environment. Sustainability development includes the three dimensions of sustainability: social, ecological and economic, often referred to as people, planet, and profit.

The economic dimension considers the efficient use of resources to ensure the long-term economic survival, good levels of competitiveness. The ecological dimension focuses on the natural environment, the availability, use, and treatment of natural resources. The social dimension focuses on human well-being, society, inter-societal relations, and equity (fig. 5).

The Committee on Development calls on the Committee on the Environment, Public Health and Food Safety, as the competent committee, to include the following proposals for Sustainable Development Goals (SDGs) in its motion for a resolution:

- proposal for a regulation on eco-design of sustainable products;
- a legislative proposal on the substantiation of environmental claims;
- a proposal on the effects of climate change on agricultural workers in the textile sector;
- minimising possible contradictions and building synergies with development cooperation policy for the benefit of developing countries and enhancing the effectiveness of development cooperation;
- identifying and addressing environmental, labour and human rights risks from non-EU textile and clothing production;
- move towards a holistic approach and investment along the textile value chain for sustainable and circular textile and clothing production.

Fig. 5. Sustainable development "pyramid" (including for the textile industry)
promoting sustainable production practices in the textile industry, including through the implementation, monitoring and evaluation of the Sustainability Compact as a tool to promote workers' rights;

raising awareness of the impact that 'fast fashion' and consumer behaviour have on the planet;

a Commission proposal for a directive on corporate sustainability due diligence to address specific problems in the textile sector and provide additional support to partner countries, in particular local actors;

reviewing the existing EU legislation to tackle unfair commercial practices in the textile and clothing (T&C) sector through a regulatory approach, including by banning unfair commercial practices for companies operating in the EU single market;

a proposal on structural racism related to indigenous crafts;

establishing of an appropriate cycle to avoid harmful practices resulting from the disposal of clothing and supplies;

increasing the capacity for repair and reuse of clothing and consumables in Europe;

investments in recycling/repair infrastructure in developing countries increase their capacity to recycle and repair clothing;

reviewing the linear nature of the textile industry in order to reduce pollution and waste, in particular the tons of microplastics;

establishing an effective mechanism to control the export of used textiles to prevent illegal shipments to third countries establishing EU criteria for labeling waste streams as second-hand goods to avoid circumvention of controls;

a revision of the Waste Framework Directive planned for 2024 on specific individual targets for textile waste prevention, textile reuse, preparation for reuse and recycling;

strong promotion of the reuse sector to tackle "fast fashion";

strengthening the demand for innovative solutions (such as machinery, equipment and digital platforms) to sort, reuse and manage the collected textile waste up to the recycling stage;

promotion by the EU of the ratification of all ILO conventions relevant to the textile industry in partner countries;

providing more reliable information and disclosure of the impacts of the T&C industry on the environment and especially on biodiversity;

including in the content of a digital product passport (DPP) for textiles information on how environmental, labor and human rights standards are met throughout the supply chain;

providing an opportunity for sectoral training and education in the field of sustainable textiles;

supplementing the strategy with relevant regional and national programming for developing countries within the framework of the Neighbourhood, Development and International Cooperation Instrument - Global Europe and Team Europe initiative;

complaint mechanisms to report non-compliance with multilateral labor and environmental agreements and the systematic use of ex ante and ex ante trade sustainability impact assessments and enhanced stakeholder engagement;

effectively implement and monitor, in a publicly transparent and inclusive manner, the social and environmental conditions associated with the Generalised Scheme of Preferences (GSP, GSP+ and Everything but Arms);
improving and strengthening surveillance by Member States' customs and market authorities of T&C imports and exports;

improving accountability and transparency of brands in the T&C sector to ensure consumers' right to information;

enhanced political dialogue with producing countries regarding decent working conditions in TCLF factories [25].

The future sustainable development of the textile industry is inherently linked to a European level of acceptance of the Strategy for Sustainable and Circular Textiles. The main measures laid down in the strategy include:

- To establish requirements for eco-design of textile products for longer durability, easy repair and recycling, as well as for the content of recycled threads.
- Introduction of clear product information and digital product passport.
- Tackling greenwashing by promoting sustainable practices and certifications.
- Reducing overproduction and overconsumption and banning the destruction of unsold and returned textiles.
- Harmonized rules for the Extended Liability of textile producers with eco-modulated fees.
- Preparation for reuse as the first, mandatory step in the management of separately collected textile waste.
- To pay more attention and control on the release of microplastics from synthetic materials.
- Stimulating circular business models, including the reuse and repair sectors.
- Encouraging companies and member states to support the objectives of the Strategy [26].

The strategy proposes actions for the entire life cycle of textile products, combined with measures to support the ecosystem in the ecological and digital transition. It examines the way in which textiles are designed and consumed, paying attention to sustainable technological solutions and innovative business models. The key areas are:

**The Strategy regarding fast fashion.** Much of the pressure on textile consumption is due to fast fashion - cheap, low-quality clothing that is produced very quickly, often under poor working conditions outside the EU. The strategy addresses the challenges of fast fashion from both a demand and supply perspective.

For manufacturers, mandatory requirements on textile design and wider use of extended producer responsibility schemes will help to extend the life of clothing.

Through the transition pathway, the Commission will work with stakeholders to scale up resource-efficient production processes, reuse, repair and other new circular business models in the textile sector.

The strategy encourages Member States to support the reuse and repair sector at national, regional and local level and to adopt tax breaks and other favorable tax measures for this sector.

As for consumers, the strategy will encourage a shift towards quality, durability, longer use, repairs and reuse. Through the European Circular Economy Stakeholder Platform, designers, manufacturers, retailers, advertisers and citizens will mobilize their efforts in the process of redefining fashion in the EU.

**The Strategy regarding microplastics.** Textiles made of synthetic fibers such as polyester and acrylic are one of the main sources of unintentional release of plastic microparticles into the environment. These plastic microparticles are released at different stages of the product's life. Consideration will be given to including measures to prevent and reduce the unintentional release of microplastics in the mandatory design requirements to be introduced by the Ecodesign Regulation for sustainable products and in the Commission's initiative to tackle the unintentional release of microplastics into the...
The Strategy regarding the export of textile waste. The Commission’s proposal for new EU rules on waste shipments will allow the export of textile waste to non-OECD countries only under certain conditions. Countries must notify the Commission that they wish to import this waste and demonstrate their ability to manage it in a sustainable manner. In order to avoid waste being labeled as second-hand goods when exported from the EU, the strategy proposes the development of specific EU-level criteria for the correct classification of waste.

The Strategy regarding the social aspect of the textile industry. The strategy includes both environmental and labor related measures to promote greener and fairer cross-border value chains. Internationally, as stated in the Communication on Decent Work Globally, the Commission will promote decent work in bilateral relations and multilateral fora. It will focus in particular on gender equality, as 75% of those working in the clothing sector worldwide are women. In addition, through the “Better Work programme”, the Commission continues to support partner countries outside the EU to improve working conditions and respect international labor standards. In parallel, the proposal for a directive on corporate sustainability due diligence introduces an obligation for very large companies to carry out corporate sustainability due diligence to address the negative impact on human rights and the environment of both their own activities, as well as in their global value chains.

Under the EU Skills Pact, workers in the textile sector will have opportunities to upskill, retrain and acquire new skills. This will lead to greater age and gender diversity in business management. The EU will continue to support the sector and those working in it through its funding programmes.

Cooperation of EU with international partners to promote sustainable textiles globally. About 73% of the clothing and household textiles consumed in Europe are produced and imported from countries outside the EU. The Union is a net importer. The strategy therefore promotes international cooperation to reduce negative environmental and social impacts. In order to promote sustainability in the textile sector, the EU will seek progress in international groups (G7, G20), in the context of the Global Alliance for Circular Economy and Resource Efficiency and in the UN Environment Assembly. The Commission will work with other partners at global, regional and bilateral levels to promote cooperation and initiatives to support sustainable value chains in the textile sector and sustainable fashion.

The Strategy for businesses and producers. The sector will need to integrate circularity principles into its business models and minimize its environmental footprint. These efforts will open up new business opportunities and strengthen the resilience of the sector. The Commission will support the sector in this transition by committing to a transparent transition path with economic operators in the textile industry.

The transition path. The transition path will be a long-term plan to realize the ecological and digital transition of the textile ecosystem and to improve its resilience. It will address the need to embrace innovation and digitalization, transform the way we
produce, use and dispose of textiles and invest in a workforce with the right skills. It will include a detailed description of the key actions to be taken and objectives and commitments. Indicators will be used to assess and monitor results over time, the impact on the competitiveness of European businesses and possible innovation needs and investment shortfalls.

The Commission invites all stakeholders, in particular SMEs, public authorities, social partners and research organisations, to express their views on how best to make the transition while increasing resilience. All of them can provide feedback in an online survey.

The transition to a circular economy is expected to not only provide environmental and societal benefits, but also unlock significant economic opportunities in the fashion industry by better capturing the value of underused and landfilled or incinerated clothing.

Ten call-to-action can help accelerate the transition to a circular economy for textiles and make it as impactful as possible (table 1):

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<th>Table 1. Calls to accelerate the transition of textiles to a circular economy.</th>
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<td><strong>Source:</strong> PACE [29].</td>
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- **Incentivize and Support Design for Longevity and Recyclability**
  - Textile products can be designed to last a long time by using high-quality fibers, making them easy to repair, and designing ‘timeless’ styles. Recyclability can be built in by using safe materials that are easy to disassemble, as well as focusing on homogenous fibers rather than complicated blends. Incentives and support are needed to encourage this approach in the design stage.

- **Produce Virgin Natural Fibers Sustainably, Including Land Use**
  - Focus on working to produce virgin plant-based fibers such as cotton in a more sustainable way.

- **Encourage the Market to Use Less Clothing, and for Longer**
  - Buying less, buying second-hand, supporting sustainable fashion, and keeping clothes in use for longer.

- **Guide and Support New Business Models for Environmental, Financial, and Social Triple Win**
  - Subscription, rental, and reverse-commerce need to be designed with environmental, social and financial impacts in mind, so that they can grow and contribute in a meaningful way to the wellbeing of people and planet.

- **Where Used Textiles Trade Occurs, Ensure Environmental and Socio-Economic Benefits**
  - Around 70% of textiles collected for reuse is sent overseas, but much of it is likely to end up as waste rather than actually being repurposed or recycled. The used textiles trade should be managed to ensure environmental benefits and help preserve local industries.

- **Strategically Plan Collection, Sorting, and Recycling Operations**
  - Collection and sorting of used textiles is very labor-intensive, and recycling facilities are large-scale projects requiring long-term investment.

- **Increase Efficiency and Quality in Textiles Sorting**
  - The quality and safety of recycled textiles strongly depend on what goes into them.

- **Make the Recycled Fibers Market Competitive**
  - Only when recycled fibers are market competitive can businesses adopt them on a significant scale, and in turn further stimulate the development of recycled material supply chains.

- **Integrate and Advance Decent Work in the Transition to a Circular Economy for Textiles**
  - Shifting employment from farming and manufacturing to later stages of the value chain such as repair, resale, sorting and recycling. It provides the potential for higher quality jobs, especially for informal workers, improving working conditions and safety, as well as wages and social security.

- **Investigate the Socio-Economic Impacts of a Circular Economy for Textiles**
  - There is a lack of quantitative research to understand the potential socio-economic effects of increased circularity in textiles.
Sustainability is a constant measure of efficiency in economic activities and a requirement for competitiveness. The sustainable development of the textile industry is based on a sustainable and circular industrial model that relies on sustainable raw materials, sustainable industrial processes and sustainable products derived from secondary materials.

3 Conclusions

The textile industry in the context of the circular economy and the Union’s policies should lead to improvements in the environmental performance of textile raw materials and materials, production, consumption, textile waste management, as well as their reduction, recycling, processing and environmental impact calculation. The sustainability of the textile industry can also be realized through the development and implementation of digitalization.

Sustainability development of textile industry includes the three dimensions of sustainability: social, ecological and economic, which can be implemented in the context of the circular economy, digitalization, Sustainable Development Goals and EU strategy for sustainable and circular textiles for the textile industry, in line with Europe 2030 policies.

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