Sustainability in the Textile and Clothing Value Chain

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Textile and clothing is one of the most important industrial sectors, not only due to the significant number of jobs generated, but also because it addresses one of the people's fundamental needs (clothing). It is, however, a sector with a huge global environmental impact, and also an important negative social impact, especially in developing countries. Sustainability in the textile and clothing value chain is a known issue, concerning both environmental and economic-social facets of sustainability. One way to improve sustainability in this sector is by measuring and monitoring the environmental, economic and social impacts of activities along the value chain and, ultimately, computing an environmental and circular score for each batch of textile and clothing product, and an economic and social score for each involved company, reflected in their products. The consumer will then have the opportunity and responsibility for selecting products with the least negative environmental, economic and social impact.

Keywords: textile and clothing ; value chain ; sustainability ; traceability

1. Introduction

The textile and clothing (T&C) sector is an important part of the European manufacturing industry, and it plays a crucial role in the general economic and social well-being. According to Euratex, in 2021 this industrial sector had more than 143,000 companies, employing 1.3 million people and generating a turnover of €147 billion, 56% from textiles and human-made fibers, and 44% from clothing. Italy, Germany, France, Spain and Portugal account for three quarters of the European Union (EU) production in this sector [1].

The textile and clothing value chain, from the creation of raw materials to the creation of the final product, is long and very diversified in terms of the raw materials used. There are raw materials of different origins such as natural fibers, like cotton, linen, wool, silk, etc.; artificial fibers, like viscose, modal, etc.; and synthetic fibers, like polyester, nylon or acrylic. There are different industries associated with creating these different raw materials.

Regardless of the types of raw materials used, creating a textile or clothing item typically involves the following main activities [2][3]:

- Spinning: A fiber processing technique where fibers undergo preparation, drafting, and twisting to transform them into yarn. During spinning, the fibers are drafted, or attenuated, to achieve consistent thickness, and simultaneously twisted to bind the fibers together, resulting in the formation of yarn;
- Weaving: A method of fabric production in which two sets of yarns, known as the warp and weft, interlace with each other at right angles to form a woven fabric. These interlacements create a stable and structured fabric.
- Knitting: A technique where loops of yarn are interlocked to create fabric. It involves manipulating a set of knitting needles or a knitting machine to form rows of interlocking loops.
- Printing, dyeing, and finishing: Printing involves adding colors, patterns, or designs to fabrics, enhancing their visual appeal. Dyeing provides fabrics with vibrant and consistent colors while finishing treatments improve their appearance, texture, and performance.
- Textile manufacturing: The process of transforming fabric into garments or textile products through cutting, sewing, and assembling. The final outcome is a completed garment or textile product ready for distribution or sale.

Each of these activities or steps in the value chain involves a series of industrial processes that are performed by different industry types and different companies, and impact the environment in different ways [4]. These companies may be located in places, and countries, that are far from each other, which leads to large displacements. In other words, products

(raw materials, intermediate products, or final products) may travel many kilometers from the creation of the raw material to reaching the final consumer.

The fabric itself is sometimes made up of different types of yarn. For example, a fabric maybe composed of cotton, wool, polyester, nylon, etc. This increases the number of companies involved in the creation of a piece of textile or clothing and increases the complexity of the value chain.

Producing different raw materials causes different impacts on the environment, making some materials more harmful to the environment than others. In the end, creating a piece of textile or clothing can be more, or less, harmful to the environment [5].

With economy globalization, also in the textile and clothing sector, and the search for cheaper labor by the companies, products and by-products often travel many kilometers around the world. These transports usually have a great negative environmental impact.

With regard to the social factor, some companies treat their employees better than others. Some companies pay better wages, provide health insurance, fairer working hours, and other perks. Companies that give fewer perks to their employees normally produce cheaper products, achieving market advantages.

Consumers need, and deserve, to be informed about the social and environmental impact of the piece of textile/clothing they are about to buy, in order to decide what to buy according to their conscience.

The need for safe and reliable information on the sustainability of textile products derives from the great impact that this sector has on the environment and on people's lives, especially in developing countries with precarious social and working conditions and corruption. According to the Global Fashion Agenda 2019 Pulse of the Fashion Industry report, the industry's social and environmental performance has improved, but the global fashion industry is still far from being considered sustainable. So, increasing the supply chain's traceability and transparency is one of the priorities specified, in order to raise the degree of sustainability [6]. To promote this view, Fashion Revolution publishes an annual report on transparency in the fashion industry (Fashion Transparency Index), using a methodology to compare brands and taking into account five key areas: policy and commitments, governance, supply chain traceability, supplier assessment and remediation, as well as concerns like gender equality, decent work, tackling climate change, and responsible consumption and production [7]. According to this report, no brand (of the 200 included in the study) has transparency levels above 70%, while the great majority (90%) has transparency levels below 50%. Additionally, it shows that, of the five areas assessed, traceability has the lowest average score [7].

The European Commission is working on establishing sustainability principles and other appropriate ways to regulate multiple aspects of product life cycles to improve product durability, reusability, upgradability, and reparability, as well as addressing the presence of hazardous chemicals in products and increasing their energy and resource efficiency, as part of its Circular Economy Action Plan [8]. The Action Plan mentions "mobilising the potential of digitisation of product information, including solutions such as digital passports, tagging, and watermarks [8]. The Wuppertal Institute has released a wide definition of a digital product passport (DPP), defining it as a data collection that summarizes a product's components, materials, and chemical compounds, as well as information on reparability, spare parts, and proper disposal instructions. The data contained in the DPP are collected from all phases of the product life cycle and can be utilized to optimize design, production, usage, and disposal [9][10].

2. Existing Solutions for Traceability in the Textile and Clothing (T&C) Value Chain

In [11], Kumar et al. proposed a system based on a relational database management system (RDBMS) and extensible markup language (XML) to register information, with the purpose of tracing a textile item's lifecycle within a value chain operator of the supply chain as well as more complex inter-actor value chains.

Agrawal et al. [12] suggested a traceability solution that relies on quick response (QR) code tags that are mapped with a secure code to add an extra layer of authenticity and verification to combat the industry's susceptibility to fake goods. This is ideal for a circular economy (CE) model, provided that these tags last long enough until the user chooses to recycle.

Besides traditional supply chain management implementations, blockchain-based solutions have also been proposed to tackle the transparency issues identified in the (T&C) value chain. Blockchain is a decentralized, distributed, and immutable database of transactions that can be tracked and verified. It has been applied in a number of financial uses

because of these distinctive qualities. To enhance transparency, and traceability in particular, there has been a shift toward exploring these uses in the context of supply chains [13]. Blockchain implementations can bring benefits in terms of decentralization, auditability, autonomy and transparency [3].

A blockchain-based traceability framework for the textile business sector has been proposed by Agrawal et al. [13]. The authors propose a distributed ledger configuration structural solution for applicability on their use case while maintaining data safety and trust among the value chain operators and securing interactions between operators.

In [14], Pérez et al. explore how the application of blockchain technology can aid in the authentication of participants in the (T&C) supply chain as well as the identification of goods' sources. They came to the conclusion that the use of a permissioned and open distributed ledger to keep significant data from the transactions of the manufacturing processes would be advantageous for the ultimate aim of textile traceability, using a case study of a woman's shirt.

The work of [15] integrates the use of blockchain with big data to enhance supply chain traceability and information sharing in the textile sector, a recurrent issue due to the global scale of the industry. It resulted in a solution that greatly reduces the risks associated with centralized information systems, and allows a more secure, distributed, transparent, and collaborative system by providing real-time information on the state of textile products to all participants in the supply chain.

In [16], the authors study the way German companies in the (T&C) sector are dealing with sustainability, how they are preparing for the transition to the CE and the role that digital technologies can play in that transition. The authors conclude that these technologies still need to be further explored and new approaches must be developed.

From the surveyed solutions for traceability in the T&C value chain, one can see that all enable tracing a product along the value chain, and most have IoT integration. However, only some of the solutions offer support for the circular economy, in the sense that they allow the traceability of products to continue after these are returned by the end customer for recycling. Some of the solutions focus on offering traceability information to the business players along the value chain (B2B), while most enable traceability information to reach the end costumer (B2B2C). None of the surveyed solutions allows the traceability of sustainability indicators, nor offers a measurement of the environmental and/or socio-economic impact.

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