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Textile Sector and Recycling: A Review on the Ecological and New Circular Economy

Bouazizi N*

Normandie University, UNIROUEN, INSA Rouen, CNRS, COBRA (UMR 6014), 55 rue Saint Germain, 27000 Evreux, France

***Corresponding author:** Bouazizi N, Normandie University, UNIROUEN, INSA Rouen, CNRS, COBRA (UMR 6014), 55 rue Saint Germain, 27000 Evreux, France, Tel: +33-0605725200, E-mail: bouazizi.nabil@hotmail.fr

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Abstract

Over the past few decades, the circular economies push the boundaries of environmental sustainability by highlighting the notion of innovative goods, creating a viable relationship between ecosystems and economic growth. This manuscript is a mini-review aims on the regulation of textile production and consumption, which should go hand-in-hand with technological innovation, favoring renewable fibers and fabrics, product design that facilitates longer use and reuse, and efficient production processes that generate less waste and fewer emissions. The circular economy models and strategies are studied in terms to gain a more comprehensive understanding about the place of life cycle assessment of textile products. A shift to a circular system for textiles requires a fundamental systemic change throughout the whole value chain of textiles supported by adequate policies. It was established that circular business models could play an interesting role in making sustainable choices more attractive. Results showed that, changes in the attitude of both consumers and producers towards durability, repair, reuse and recycling is key for generating the environmental and economic benefits that circularity entails. In addition, service-based models, such as the leasing of clothing, can increase more durable and repairable designs and then, the use of recyclable materials. Accordingly, circular economy and life cycle analysis of textile materials have been studied to optimize the environmental impacts.

Keywords: Life Cycle Analysis; Circular Economy; Ecosystem; Textile Industries

Introduction

The textile industry uses vegetable fibers such as cotton, animal fibers such as wool and silk, and a wide range of synthetic materials such as nylon, polyester, and acrylics [1,2]. The production of clothing requires different resources, starting with water for the cultivation of raw fiber and dyeing process [1-8]. Although, the industry accounts 8% of greenhouse gas emissions, 20% of industrial water pollution globally and workers face issues such as hazardous environment and low wages [6-9]. While, the major air pollution problem in the textile industry occurred during the finishing stages, where various approach are employed for the treatments of fabrics. In addition, the textile industry can generates various forms of pollution during the production of fibers such as the uses of pesticide, fertilizers and dyes toxic products loaded in water, during the fiber production [10-14]. The production and transport of textiles generates around 1.2 billion tons of greenhouse gases per year, which is more than all international flights and maritime transport [1-5]. Long chain for the production of garment and each step may take place in a different country, where the greatest carbon impact. Regarding to the above problems it is the time to make decision on the concept of a circular economy to analyze its promise for businesses and economies [15-20]. However, in the face of sharp volatility increases across the global economy and proliferating signs of resource depletion, the call for a new economic model is getting louder. Recent research for a substantial improvement in resource performance across the economy have been started to explore pathways to reuse products and restore more of their precious material, energy and labor inputs [20-24]. Therefore, the following queries are still opened for

concrete answers:
(i) How does the circular economy compare to the race to improve efficiency?

(ii) What are the benefits of a restorative model to businesses and the economy?

In order to answers the above interrogation, the present mini-review investigate the actual development of a powered solution to increase the production without affecting the environment.

Methodology

A communication of literature from current and archive-based journal articles and patents were employed for the creation of a timeline, plotting protein-based fiber technological innovations against key social, technological events around the globe. In terms of a contemporary fashion market, this regeneration of value supports a circular economy of goods including textile fibers through recycling and reuse.

The industrial revolution and its environmental impacts

Unlike, the modern fibers which contain several hazardous substances, which affects the environment and to health, these harmful substances generates a cancer or neurological development problems [25-27]. For example, heavy metals that make our clothes shine or substances used in the manufacture of technological textiles caused health effects, which were still do not know (Figure 1). Recently, the end consumer remains in constant contact with these products by wearing clothes and allowing all these harmful substances to penetrate through the skin [28-30]. Textile workers are constantly exposed to these chemicals, which produce more harmful products for both humanity and environment [31-35]. In this regard, for the first time, several textile companies like Adidas and Nike groups to Chanel and Prada, via H&M and Gap, have decided to reduce the carbon footprint of the clothing sector. These fashion giants signed a "Fashion Pact" aiming to achieve zero net carbon dioxide emissions by 2050 and to switch to 100% renewable energies across the entire supply chain by 2030 [36].

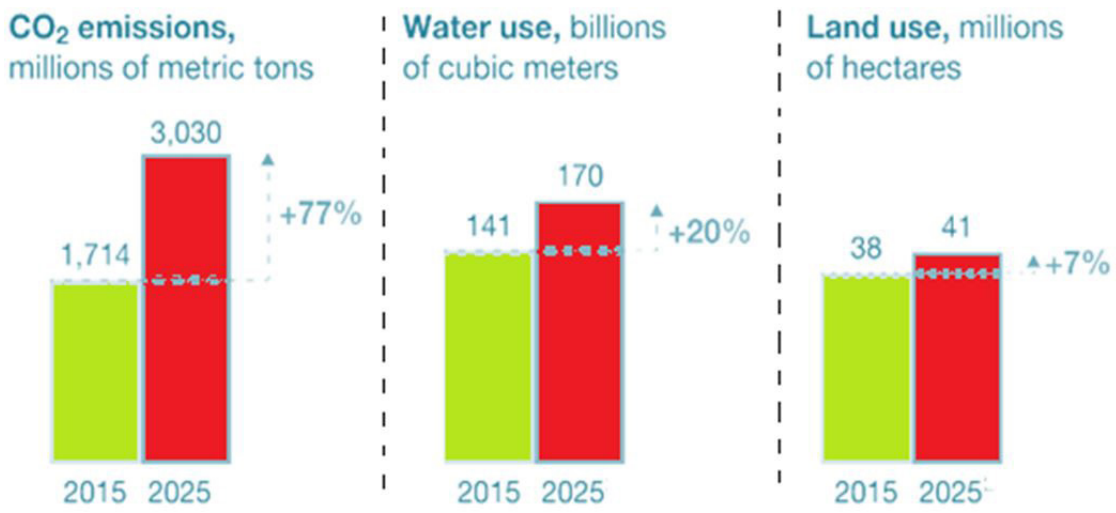

Figure 1: Evolution of the environmental pollution [37]

According to the European Environment Agency (EEA), the amount of clothing purchased in the European Union (EU) increased by 40% between 1996 and 2012. In 2015, Europeans acquired 6.4 million tonnes of new clothes and shoes, according to a European Parliament study [36]. Globally, the trend is the same: 100 billion items of clothing were consumed worldwide in 2014, according to Greenpeace. This frenzy of consumption has experienced a leap since the 2000s. Consequently, the environment impact was considerably increased, particularly, the CO_2 emission and water uses (Figures 2 and 3).

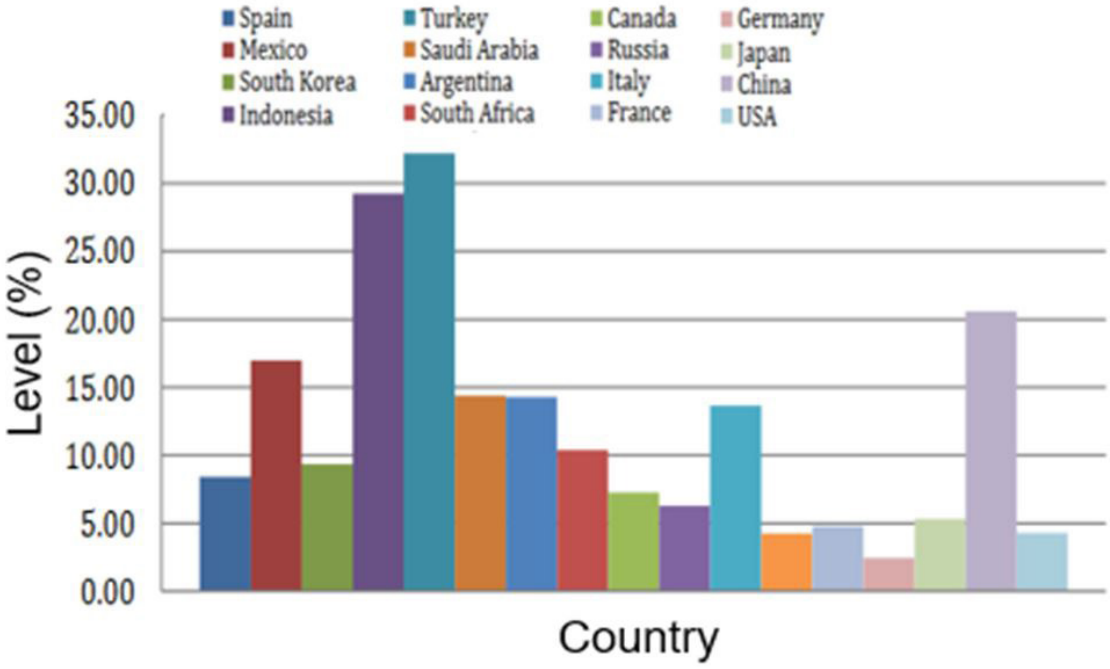

Figure 2: Water pollution caused by the textile industry [36]

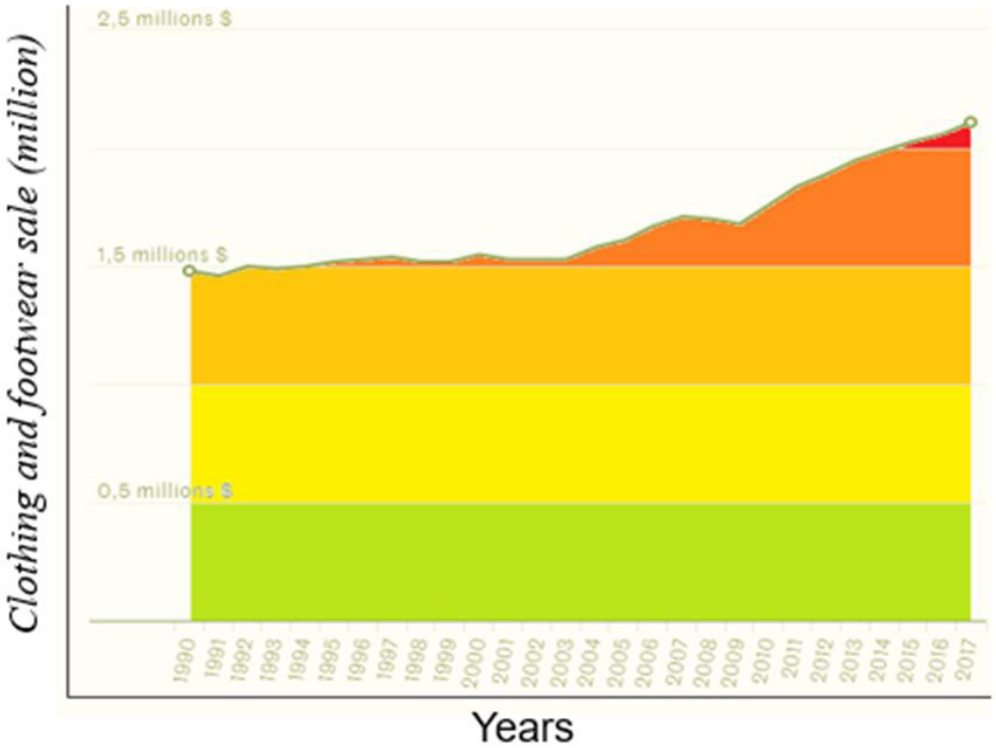

Figure 3: Evolution of Clothing and footwear sale per year. The beginning of the 2000s was accompanied by an explosion in sales with the proliferation of collections offered in stores and the success of online commerce [36]

Textile recycling as a solution for environment protection

Recycling of textiles is a good technic for business, as well as for the environment protection. This evidences several types of recycling, such as the mechanical and chemical approach.

Mechanical recycling

Mechanical recycling is the most used methods and focalized on the recovers of fibers textiles after mechanical treatment. It includes many steps, firstly, the unraveling gives fibers shorter than virgin fibers that restricts the outlets and directs them mainly to textiles techniques. Secondly, the shredding makes textiles and shoes are shredded in small pieces that can be amalgamated in aggregate thanks to compounding or reduced to powder state. Finally, the defibration patented process and makes it possible to recover long fibers that can be rewoven or re-knitted in new textiles.

Chemical recycling

Chemical recycling consists on the regeneration of chemical and synthetic fibers. The regeneration-involved processes of dissolution allowing depolymerization of fibers textiles into molecules, and then repolymerized to obtain new fibers. The obtained fibers can be employed in substitution of virgin fibers. For example, new techniques have appeared lately allowing the treatment of cellulosic fibers. Up to now, the chemical recycling, mainly used in Asia, is still underdeveloped in Europe [38,39]. Chemical recycling technology presents some disadvantages and danger for the environment such as the short life cycle and the non-guaranty for continuous protection of environment. For this, chemical and mechanical recycling were considered as limited and not sufficient for a durable ecosystem in the near future. Therefore, alternative solutions are requested for circular economy.

Life cycle assessment on textile materials

The production and transport of textile products are the phases with the greatest environmental impacts. The application of the LCA to the textile industries on wastewater treatment and energy consumption, it clearly depicted that non-controlled LCA introduces a higher environmental impact, owing. Solution were obtained in this regard, where combination of two or more concepts for LCA can decreased the environmental impact. In addition, it is not surprising that initially an energy analysis or process chain analysis theoretically evolved as an important contribution to life cycle analysis. Thus, examination of energy system is of great interest during the LCA, which played a key role not only on the environment protection, but also the technology innovation of the enf textile products.

Moreover, the main levers for reducing the sector's footprint is to reduce the purchase of new clothes and therefore to lengthen the period of use of each garment as much as possible. Nowadays, the average lifespan of a garment worn in the Europe in 2015 is estimated to be 3.3 years 26 [40-42]. The quality of the fabrics selected is a determining factor in the longevity of the garment. Afterward, the marks must test the durability of their products based on objective and comparable criteria. Herein, some brands offer products under warranty and thus take responsibility for the quality of the textiles they place on the market. A few even provide a guarantee for refurbished clothing. In addition, clothes can be designed to be multifunctional, worn on multiple occasions and in different conditions, reducing the need to purchase multiple parts [43-45]. Another way to extend the lifespan, the second-hand clothing market is growing, encouraged by digital. Thus, by taking into account the LCA, the environmental issues evidenced numerous opportunities for the textile industry to reinvent.

New circular business models

A sustainable textile system should bring wellbeing and value to society through the provision of safe, while at the same time minimising any negative environmental and social impacts. Across the value chain, pollution and waste should be limited. To ensure the conservation of materials, new circular economy and recycling processes should be validated, allowing high-quality, clean and safe product and materials cycles (Figure 4).

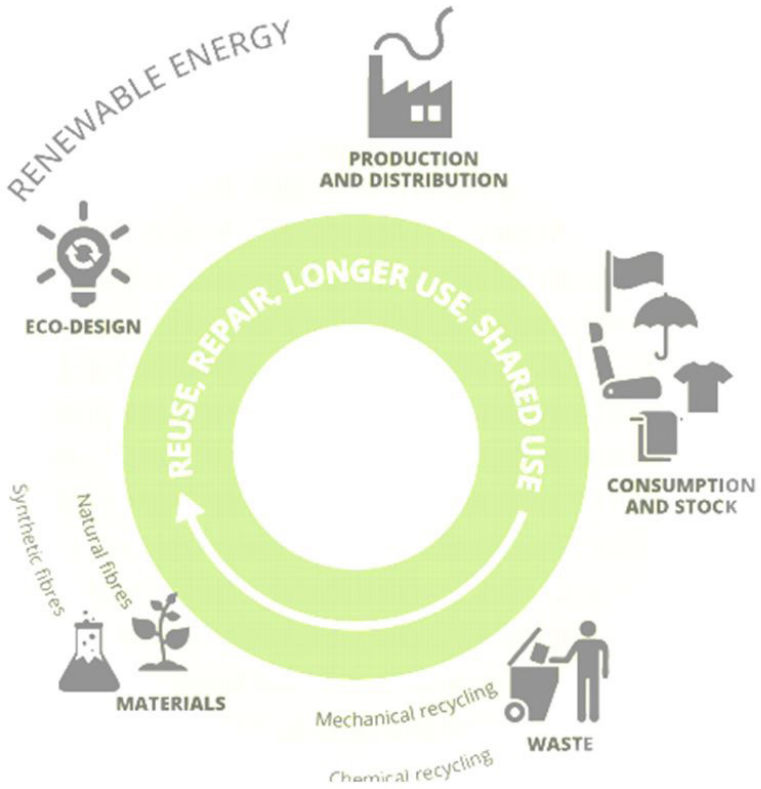

Figure 4: Illustration of the circular economy for textiles

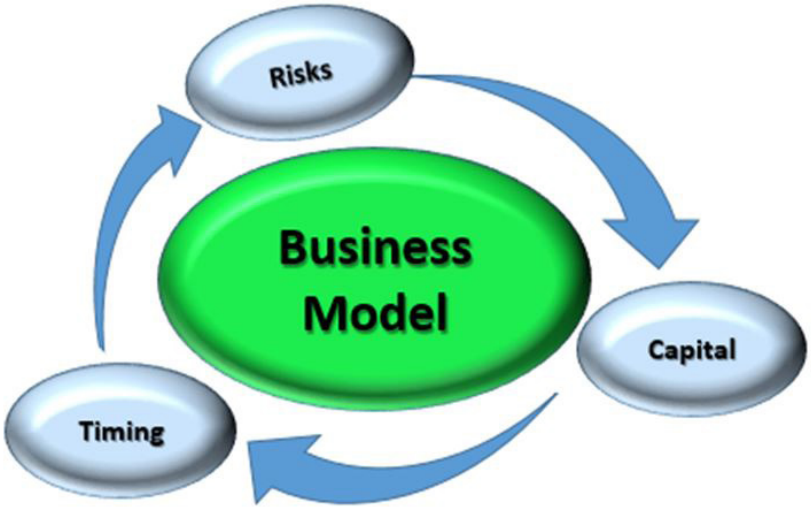

Figure 5: Relationship between risks, capital and timing for new business model

Recently, a decrease of the worn garment before being thrown has fallen by 36% and the relation to the clothing property could be reconsidered by the circular economy [46,47]. In this regard, the production and innovative design goes hand in hand with business model, suggesting a coherence and tendency to ensure the links between risks, capital and timing (Figure 5). The holistic innovators will think carefully of all the necessary enablers for their innovation like the ecosystem oriented and of the fair and creative way to share the value among their contributive partners, including their users [48]. In order to lie between business models, the last one i.e. business design must be able to quality of products and service.

In other words, it is interesting to use a new business models to unleash competition and innovation in the power industry. To prevent our clothes from sleeping in our closets, new business models, based on the functional economy, are emerging [48-50]. The business model is the way that money flows when a product or service is delivered to a customer. This might encompass things like upfront costs, various revenue streams, and risk allocation. Accordingly, selling products and brands can offer repair services in order to encourage their customers keeping their clothes as long as possible. It results in consumer involvement with increases of the emotional durability of textiles [52-55]. Interestingly, the personalization services and sewing or upcycling workshops are all services appendices that could be offered by brands. These innovative marketing strategies involve the consumer allowing them to create a product that corresponds to their tastes and needs and increase its attachment, and ultimately lengthen the life of the product [56,57]. These new business models are still niches and must be supported fiscally in order to be able to scale up. Afterward, changes mark a profound change in the way clothes are worn, sold, shared, repaired and reused. Beyond the benefits environmental benefits, the societal benefits should be noted since these initiatives also allow to create new activities locally and to recreate social ties. Understanding customer needs and seizing the economic opportunities that come with them is essential arise. All actors must be mobilized to contribute to these profound changes in consumption patterns.

Multifunction of ecosystems towards a circular economy

Circular economy is an ecosystem where fundamental principle is to maintain resources withdrawn and coming from the environment in the economic circuit (Figure 6). Thus, extending their life cycle and avoiding their return in the form of waste [58-68]. The strategy is able to generate a powered idea and allows programs in the value chain to enhance its efficiency. Consequently, the unnecessary consumption and the need for excessive extraction of resources from nature will be decreased. The decreases of the need for natural products and energy mitigate the effects and impact of human activity on the environment. It contributes the research for a new employment rather than the natural resources. The concept of circular economy itself circulates in our day-to-day lives, however it often lost when using it. The transition to this type of circular economy is facilitated if we work on the existing measurements and proposed solutions. Afterward, it can promote circularity and on the application in the various stages of the value chain.

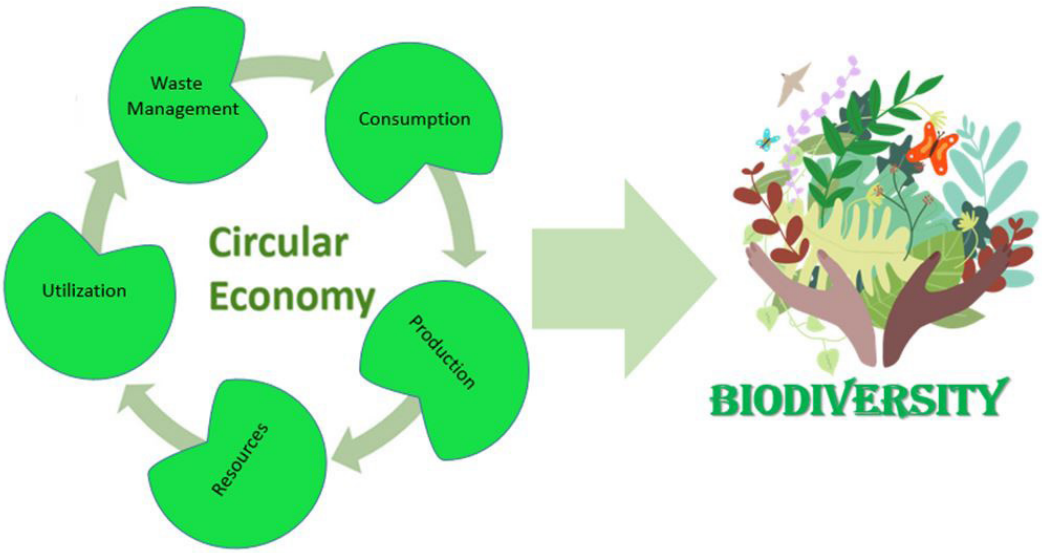

Figure 6: Schematic illustration of a circular economy as a pathway for efficient organizations

Accordingly, the value chain, pollution and waste should be limited to ensure the conservation of the value of materials, resulting in high-quality, clean and safe product and materials cycles.

Therefore, we can consider five R's: Refuse, Reflect, Reduce, Reuse and Recycle [68-70]. All sectors, one way or the other, benefit from the transition to circular economy, but these advantages vary according to their intervention in the value chain, for example: Collaboration is an important key to success towards a circular economy (Figure 7). For this, all stakeholders must agree to act in the same direction as the innovation, the sharing of good practices and the quantified objectives. In addition, a powerful innovative ecosystem is necessary to ensure the scaling up of good existing solutions. In this regard, many companies are flowed by an interactive strategy respecting the above direction. The tool allows companies to compare their performance against other players in the market and helps them prioritize actions. By listing all the good practices, companies benefit from the experience of other brands while increasing their profitability.

Figure 7: The stages of the value chain

In other hand, the circular economy advocates for bio mimicry, ecosystem service valuation, bio economy, and renewable energy. In this regard, given the imminent need to protect biodiversity, the authors call for further research on the interaction between biodiversity and the circular economy, and for circular economy advocates to explicitly acknowledge the concepts limitations [60,61].

Multifaceted innovation centers

Face to the development of innovative centers and corporate startups accelerators, it's necessary that innovation centers shared the same goal and space, as well as training, mentoring, and supporting resources (Figure 8). In fact, the used methodological approach can build a fulfill business model and design a meaningful product and service in short cycles including user feedback [71,72]. Nerveless, the grown an innovation unit and the network to engage the corporation on the creative product is requested to ensure the fruitfully mutualized across intrapreneurs, startups, and corporate innovation teams. Furthermore, it's of great importance to select the criteria and committees for these different progression and powerful programs [68-72]. While they are not identical and could be largely aligned, also the problems that they want to be solved. Finally, it can establish a solid common ground to nurture the various programs and shared mentors or sponsors used to coach startups or intrapreneurs.

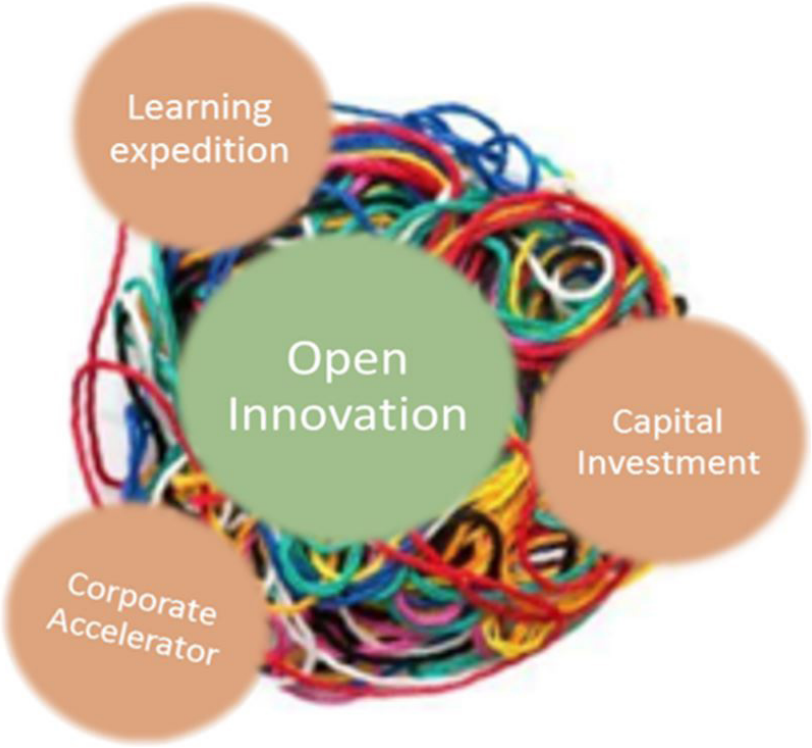

Figure 8: The methodological approach to build a value proposition, fulfill a business model canvas, design a meaningful product and service in short cycles including user feedback

Conclusion

Textiles play an important role in the entire world manufacturing industry to economic growth and job creation within abroad. However, textile production and consumption patterns generate significant and growing negative environmental and social impacts. These include wasteful resource use, ecosystem pollution through eutrophication and the dispersal of hazardous chemicals, contributions to climate change and competition for land and water. In addition, its linear value chain makes the textiles value chain one of the most polluting and resource-intensive production and consumption systems, especially in the production and use phase. Therefore, face to these problems, it's still required to move towards a more circular and sustainable system allowing to go beyond separate collection of textile waste and recycling. Afterward, the circular management of textiles requires the creation

of safe product and material cycles, encouraging reuse, recycling, while avoiding waste incineration, and landfilling. The powered circular economy offers solutions enabling the fashion industry to rise to the challenge environmental without denying what makes its specificity, creativity, design and the well-being of users. As initiatives emerge, the sector is mobilizing to seek out innovations and new business models that can fundamentally change the way to produce and let consume fashion.

Conflicts of Interest: The authors declare no conflict of interest.

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