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Circular Economy in Textiles and Apparel

Processing, Manufacturing, and Design

Edited by Subramanian Senthilkannan Muthu

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Woodhead Publishing in The Textile Institute Book Series

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WOODHEAD PUBLISHING
An imprint of Elsevier

Woodhead Publishing is an imprint of Elsevier
The Officers' Mess Business Centre, Royston Road, Duxford, CB22 4QH, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States
The Boulevard, Langford Lane, Kidlington, OX5 1GB, United Kingdom

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Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-0-08-102630-4

Publisher: Matthew Deans
Acquisition Editor: Brian Guerin
Editorial Project Manager: John Leonard
Production Project Manager: Sojan P. Pazhayattil
Cover Designer: Victoria Pearson

Typeset by TNQ Technologies

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Introduction and the concept of circular economy

1

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1.1 Introduction

Matter and energy cannot be created or destroyed. Matter and energy also tend to disperse. These are two major laws of thermodynamics referring to infinity, on the one hand, and entropy, on the other. Infinity, because—as we will elaborate on throughout this chapter—matter is constantly changing and offers a wide range of possibilities. It has always existed and it will always exist, which leads us to the concept of entropy. Entropy refers to a measure of disorder within a system, which causes matter to change and evolve. Both concepts—infinity and entropy—are inherent to any element of nature. Every entity existing in the universe has these qualities and answers to these laws of physics. **These laws were mentioned by Ray Anderson—Founder of Interface and pioneer in the application of the circular economy as a business model—(1998) in his book "Mid-Course Correction," and they are the pillars of the sustainability paradigm**. And, of course, as sustainability is systemic, we cannot talk about sustainability without referring to the circular economy. The circular economy is based on the natural operation of the universe. It leads us to a comprehensive understanding of our context, and reappraises the resources we use to conduct an undertaking. It guides us to a more frugal, less fictitious way of living, considering every circumstance within its context and becoming aware of the impact of every action we take. Therefore, a change of paradigm is impending, perhaps not to "save the planet" or to "save humanity," but just to learn about the care and respect that every living being deserves.

The operation of the current economic system is evidenced in most industries, like the textile industry, and more frequently, in the fashion system. Over the past decades, leading industry brands have increasingly sped up the season cycles they offer and promote, and at present lack of transparency prevails. In order to meet increasingly tight deadlines, most fashion brands decide to manufacture their clothes outside the country of origin, choosing Eastern countries for this process, where production costs are much lower because labor rights are less respected as well. In these countries the working conditions are unhealthy. However, such working conditions are not restricted to manufacturing in Eastern countries, as neither is forced or child labor exclusive to the tailoring process, but go as far as every step of the production process. For

[a] The author appreciates the contribution of **Victoria Celeste Zaccari** to develop this chapter.

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00001-7

example, according to the report submitted by the US Department of Labor in 2016, in the case of the fashion industry, child and forced labor is found in Argentina and Brazil, in addition to the already known countries such as Bangladesh, China, India, Malaysia, Thailand, and Vietnam. According to the same report, forced and child labor during cotton production is evidenced in Argentina, Brazil, Paraguay, Egypt, China, India, Turkey, Benin, Uzbekistan, and Mali, among others (DOL, 2016). Astonishingly most fashion consumers are unaware of raw material sourcing, and the production, transport, promotion, and sale of the clothes or accessories they wear. However, it was proved that if this information is given to consumers, they take account of it and will most likely base their future purchase decisions on these aspects (Han et al., 2017).

Likewise, the language chosen to communicate improvement proposals should be assertive. This means that, instead of focusing on what is done wrong, it is more effective to propose solutions, showing alternatives to improve and looking for collaboration with other parts, generating empathy. By communicating and informing about other ways of making, producing, consuming, and managing resources, we are offering an opportunity for a better behavior, both improving ourselves and bringing about positive environmental changes. If everything is transformed, it should be to improve, not to impoverish.

1.2 Linear versus circular economy: conceptual differences

In general, the concept of economy leads us to think of trading systems, financial systems, investments, figures, companies, profits, losses, GDP, and other rates which, eventually, give us view of either the growth or decline of a country or region. This is a linear economic system that works as planned in the 18th century during the first industrial revolution, a time that witnessed the emergence of the economic thinking underlying the current global economies and mechanized production (Leonas, 2017). However, the world is not the same in the 21st century. We are currently operating beyond the healthy boundary. We have information and coexist with the consequences of scarce resources, pollution, and damages to soil, water, air, and biodiversity. These entail not only environmental but also social consequences. Overpopulation, poverty, epidemics, diseases, pace of life, wars, forms of employment, and food are all consequences of past decisions regarding resource management. This economic system, which involves a trading system based on mass production and consumption, could be defined with the slogan "use-dispose," since it takes large amounts of resources—abusing them, at a low economic cost—for immediate use and generates a large amount of waste. This accelerated growth and its subsequent accelerated consumption of products and resources have significantly worsened environmental problems (Radhakrishnan, 2017). By overexploiting themselves and other living beings, human beings created widespread consciousness, or rather unconsciousness,

of disposal, thus perpetuating a culture that repeats the same patterns that resulted in our dramatically accelerated lives over and over again through generations. Therefore, the economic system should be planned considering both living beings and the persistence of economic profit. That is what the circular economy is all about.

For example, the circular economy is based on four basic principles of nature (Ellen MacArthur Foundation, 2012; Weetman, 2017). These principles could be defined as follows:

- Waste as nutrients: like in nature, waste becomes food for other beings or nutrients for the soil. In the case of objects, this translates into keeping objects to be reused and redesigned in order to extend their durability by keeping all their parts with the highest possible quality. Therefore, a product life cycle can be indefinitely extended.
- Resilience: like in nature, resilience is built through species diversity. By creating a wide pool of resources, the circular economy can use them to adjust to every context and circumstance.
- Renewable energy: to create a collaborative system among the parts that provides for a flow of resources, ideas, and information—all powered by renewable energy.
- Systemic: it is based on the connection between its constituents, creating opportunities for the context where it develops, setting an example for other economies/cultures/societies.

Moreover, the linear economy is based on mass production and marketing, which speed up production and wear and tear times. Conversely, the circular economy is based on natural laws, emulating the natural cycles (Gullingsrud and Perkins, 2015). It is regenerative and restorative as to resources, societies, and the environment (Leonas, 2017). The circular economy is based on four principles: preservation of the natural capital; optimization of the available resources; risk reduction; and renewable flow of resources and products (Ellen MacArthur Foundation, 2017; Twigger, 2016). First, the preservation of the natural capital implies a reasonable use of natural resources as well as good labor conditions. This results in the optimization of the available resources, which are—currently—overexploited by different industries. Risk reduction is also related to the above in the primary sense that we could not survive without natural resources. By overexploiting resources, there is no time for their regeneration, which has a negative impact on the ecosystem. Finally, the renewable flow of resources and products is evidenced over time. Once we acknowledge time as an essential factor in every part of the production and consumption process, it becomes clear that a truly beneficial solution for the majority is to allow more time to produce goods and services that generate a positive impact on the environment, the societies, and the global economies.

Nudie Jeans is a Swedish brand that manufactures and sells jeans based on a philosophy of intimacy, both with the garment and with customer communication. On its Website (nudiejeans.com) you can find out where and how garments are manufactured. Moreover, the brand describes its raw materials for each product, means of transport and packaging in each stage, country of origin, and suppliers.

The brand is focused on transparency to build a bond of trust and intimacy with its customers.

1.3 Need for circular economy

As we have explained, to start curbing the dramatic effect of human activity on the planet, it is essential to develop an industry that considers each and every element involved.

The textile industry is one of the most polluting industries in the world, since it uses a resource-intensive supply chain that causes massive waste and releases a large amount of toxic substances that pollute air, water, and soil (Leonas, 2017). This has an impact on industry workers—who, in turn, have excessively long working hours in unhealthy conditions, in many cases risking their lives to produce more clothes at a lower cost—and on the inhabitants of the place where they operate.

Each stage of textile product life cycle generates large amounts of waste, which are currently discarded. Since—as mentioned earlier—the textile industry is part of a fashion system that promotes mass and fast consumption, people buy clothes to wear for a short period of time, so they quickly become textile waste. Waste consists of material that reaches the end of its life cycle for an individual or organization, which is generally disposed of, along with other wastes, in a landfill, which, in turn, creates problems for the environment and other sectors of society (Radhakrishnan, 2017). Textile waste can be classified into three categories (Vadicherla et al., 2017; Radhakrishnan, 2017):

- Preconsumer textile wastes: They are the remains of every production process. In the textile and fashion sector, these consist of pieces of fabric, leather, and other raw materials discarded during the textile processes.
- Postconsumer textile wastes: They are clothes no longer desirable for the user due to aesthetic, functional purpose, or fashion reasons, or because they are torn. Generally, in the best case scenario, these garments are mended and sold as secondhand clothes in developing countries.
- Postindustrial textile wastes: They are generated during the manufacturing processes. These may be gases, liquids, or solids. Among them, we can mention dyes and chemicals dumped into water streams, the carbon footprint of every process and transport, etc.

As posed by the circular economy concept, mass garment consumption entails a purchase decision process rather shorter than the conscious purchase of clothes. Therefore, time is one of the essential factors. There is a big difference between wearing clothes and getting dressed. When we get dressed, we show something about us, but when we learn about the origin of the garment, we are also embodying its history. Therefore, we can respect the context, origin, and production process of the garment, which turns it into a unique piece, and the decision process becomes more conscious. On the contrary, in the case of mass garment purchase, the process of garment purchase, wear, and discard takes place over a very brief period of time, just like its

production process. There is even less knowledge about garment origin, wear, and destination. This is the reason why the circular economy proposes not just product recycling but also upcycling, which adds value to the end product—unlike recycling, which generally consists in reusing materials, but not necessarily trying to improve the quality of the new product. Moreover, recycling is part of the 3Rs: Reduce, Recycle, and Reuse, which is just the starting point. To reduce the consumption or use of resources is a short-term solution (Gullingrud and Perkins, 2015), and it is not enough to achieve a real improvement. Conversely, it is necessary to create products made of materials that can be constantly transformed and reused (Twigger, 2016), improving end product quality every time.

Sustainable fashion brands with business models based on circular economy are currently faced with a paradox, since they promote messages of more conscious consumption to change customers' consumption patterns while trying to sell more products (Han et al., 2017). Fashion brands that truly want to implement an approach based on circular economy should develop their inventiveness, creativity, versatility, and resilience—among other abilities—to have the lowest possible footprint while offering appealing consumer products (Han et al., 2017) and setting an example for both other brands and their customers. Patagonia is a leading brand in terms of sustainability and circular economy which—being aware of the impact of human activity, especially in the textile industry—not only teaches its customers how to mend their clothes but also asks them to return the clothes that they no longer wear to mend and sell them to new customers. Another good example is Pratibha Syntex, an Indian textile manufacturer that started to recycle textiles, turning waste into recycled yarns and garments. This way, the company has not only made profit from the creation of original products but also managed to minimize waste and, more importantly, its recycling and value-creation initiatives have changed the mindset of those who are part of the company, who put creativity at the service of the available resources, and not the other way around (Fletcher and Grose, 2012).

At the beginning of this chapter, we referred to matter and energy. Both coexist and cannot be separated, as they are usually part of every element. Matter is the visible part, while energy is what we do not see. Something similar takes place in the fashion system. Certain garments or accessories convey a concept, a message, or an idea. Fashion as a language is a complex system, with codes that change over time, and varies depending on culture or context. According to Umberto Eco, after representation, the garment is always changed, "enriched" (Mikerina, 2016) and, in turn, the meaning tends to be modified by the context. In mass fashion, the meaning of garments becomes vague and plain. The materials, fabrics, and tools used in tailoring, just like the design process, are instrumental to an industry that looks to sell a larger quantity in the short term and at the lowest possible cost, leaving aside the value of each process, along with the value of human labor. Slow fashion emerges as part of the "slow" movement which promotes—precisely—giving awareness back to each process. Materials are valued, as well as handicraft work and local production (Mikerina, 2016), which turn the finished product into a unique piece. To focus design on circular economy is to go beyond the material aspect and implement positive social and cultural changes. And, as textiles are closely related to culture, they have an identity and represent both memory and legacy.

To redesign them becomes an act of creativity, respect, and evolution (Etzioni and Neeman, 2016; Li-Chou Han et al., 2016). In a way, it is all about focusing on the present, enjoying every single moment.

Finally, it should be noted that projects based on the circular economy—such as Interface, Elvis & Kresse, or Patagonia—become role models, and they bring about great changes of paradigm both with their discourse and their actions. Moreover, it is worthwhile to point out the importance of passing on knowledge both regarding material management and skills (sewing, dyeing, embroidery, knitting). It is essential to recover craftsmanship for the circular economy to slowly become a usual form of trade.

1.4 Benefits of circular economy

In order to implement a circular economy system it is necessary to understand that we are all responsible for the materials, products, or services that we use, as well as for everything we discard. This involves designers, producers, industries, transport, users, etc. The benefits of applying a circular economy system could be divided into two parts: short-term benefits, on the one hand, and long-term benefits, on the other. Moreover, to implement a system based on circular economy requires a process to transform social and cultural paradigms, rooting out customs and habits learned throughout generations so as to include others that align with the guidelines posed by the circular economy.

First, the benefits of implementing an economic system that emulates the operation of nature, like the circular economy, where waste is used as feed for a new stage, would be waste reduction and its subsequent antipollution effect on the environment, which will also prevent various diseases caused by poor waste management.

Second, the circular economy is a closed-loop system. It could be summarized with the phrase "everything comes back"—as is the case with fashion trends. This results in a continuous flow of services, goods, and resources. In turn, as it is based on the principles and cycles of nature, it also allows the necessary time and space for natural resource regeneration, since by reusing product materials several times, there is no need to constantly use original raw materials.

The references to natural resources not only include the materials used but also the water and energy that they require. Every living being feeds on sunlight and needs water. In the case of animals and human beings, our food consists of plants or animals, which, in turn, absorb sunlight. At the same time, the origin of all the materials handled by human beings can be traced back to nature. Therefore, water and energy are the natural resources that are in constant use. Precisely, these resources face a scarcity crisis. If our activities are constantly polluting water, or extracting resources from the soil, we are leaving a footprint on water availability and using too much energy. Therefore, the circular economy helps create a regeneration loop for natural resources.

According to Catherine Weetman (2017), in the United Kingdom, consumers accumulate—on average—around 28 kg of clothes per year, while an average consumer in the United States generates 30 kg of textile waste in the same period of

time (Weetman, 2017). However, companies like Worn Again, a British company that is determined to reverse this situation through recycling and upcycling, focusing on a closed-loop system, are looking for ways to minimize overproduction in the textile sector—10,000 tonnes of clothes per year (Black, 2012). Moreover, it is estimated that—in the United Kingdom—at least between 30% and 40% of textiles or garments are recycled, and that consumers are increasingly curious to learn more about recycling or customized clothing (Wheeler, 2012).

1.5 Current challenges

Now, the biggest challenge we are faced with to develop a circular economy is to openly assume our bad behavior and take responsibility for finding solutions. It is important to know the purpose of our actions. To design for longevity, design for reuse, or design for services (Niinimaki, 2017) is a way to plan the future of the materials that we use.

The type of waste that currently requires more attention is waste generated during the production process and final disposition after use (postconsumer wastes). That is the reason why the action of Patagonia toward its customers is so important, training them to mend and reuse their clothes or to return them for refurbishment and resale.

The problem with postconsumer waste is that it generally results from products that we use on a daily basis, at levels detrimental to our lives. This has a huge impact on the environment, like those we are currently faced with, but it could be managed in such a way that it becomes raw material for new products.

When considering a circular economy system, it is necessary to refer to the business model. The business model includes the company's production, internal and external communication, and marketing models. These may consist in either repairing, reusing, recycling, or reselling goods or in developing goods rental or trade services to replace their possession and prevent daily waste.

Fast fashion emerged in the 1990s in response to an increasingly accelerated demand. It works as a latent core of constant, accelerated production and consumption. It is a wheel that spins on and on, taking up everything around and returning it as waste. Now it is evident how multibrand companies attempt to compete against each other, how selling clothing items and accessories at supermarkets has been successful, and profitable, as well as the growth of online clothing sales, and the increased number of licenses granted by top brands—and even their forgery. They all result from an accelerated market that has lost control both over itself and its environment. It is vital to recover the natural pace within the fashion system, since the downside to the profit, success, and glamour achieved by these brands is labor exploitation, like child labor or unhealthy working conditions; human rights violations; neglect; and overexploitation of the resources used as raw materials in the production process.

However, there are cultures which are either excluded from or completely absorbed by this system, due to their geographic location, economic situation, or religion. This is the case of the African continent, which over the past years has made progress in terms of technology, energy, and agriculture, including the textile industry in such progress.

Some countries like South Africa or Tanzania, among others, are even participating in the Fashion Weeks of London or New York and holding fashion events as well (Shaw, 2013). The African continent has a long tradition of dressing, dyeing, and knitting that is closely related to craftsmanship and rituals. African fashion shows the continent's history and represents its present. Therefore, fashion brands know about its tradition and find the most creative ways to blend ancient techniques with modern technology. In turn, as each country has its own identity, there are multiple resources, dyes, messages, colors, and expressions. Let us analyze the case of "One Collection," from the Nigerian brand NKWO (Shaw, 2013), which is aware of the waste generated by the textile industry and uses it as raw material both for garments and textile accessories. For this reason, the brand only launches one collection a year, which has a strong Nigerian identity and highlights the positive attributes of its culture. From its conception, African design embodies the meaning of circular economy: to respect the past, adding value to it in the present so that it survives into the future.

Fabrics are the main raw material used in the textile sector. They can be natural (plant or animal origin), or man-made (based on cellulose or petroleum) (Weetman, 2017). The—natural or man-made—sourcing of a fabric does not guarantee quality or resource efficiency, in the case of natural fabrics (Weetman, 2017). This is evidenced in cotton, which is spun from the fruit of the plant, that requires very intensive farming using large stretches of land and large amounts of water. Moreover, conventional cotton usually requires irrigation systems that waste water, in addition to pesticides and fertilizers that damage soil, air, and water, and—therefore—human beings around the crop area. In turn, the farming method of organic cotton—which was developed as an environmentally friendly alternative to conventional cotton—is very expensive due to the amount of resources used, as noted earlier.

Fashion is a social process that is conceived by and expressed through people, and, as a material object, it bears a direct relationship to the environment. There is a need to create a transparent system whereby each part takes responsibility from action. A circular economy system offers tools to companies, entrepreneurs, designers, producers, consumers, and users while raising awareness. Awareness helps take responsibility to bring about change. Just like with the sustainability paradigm, we can now assert that companies are implementing business models that are migrating toward a circular economy. Consumers should be informed about the production process of the goods they use to improve their decision-making power.

1.6 Opportunities

In general, recycling is the first concept that comes up when we think about the circular economy. However, when we elaborate on this topic, we realize that it is a way to see the world. The circular economy offers the opportunity to claim back our position and reconnect with nature from the action side. When it comes to including the circular economy into their business models, companies generally raise this question: how can we do better? Therefore, they are looking for information and getting the desired results through trial and error. Every project has its own development process.

Looking for information, background, and pioneers is as important as manufacturing and then selling a product. At the time of a sale, not only are goods exchanged for money but communication with customers is also strengthened, offering information, and, if possible the story, of the product. This is the reason why the circular economy is a comprehensive system that puts all the pieces together. It is vital to know both one's own role and the context.

Beyond bonding and getting a deeper knowledge of our environment, the implementation of the circular economy offers us ways to brighten up and improve this environment. Making the most of resources and, in turn, adding to their value without overexploitation, creates a healthier environment that sets the stage for new production methods.

To achieve this, how business is usually conceived needs to be changed. The successful implementation of a circular economy system requires the restatement of the production−distribution−sale process and the consumption−waste cycle.

The opportunity of creating value from objects or materials in different conditions is worthwhile. The circular economy is a method for the responsible creation of new objects either from waste or discarded/discontinued objects.

While there are examples of business models based on the circular economy, a system needs to be developed. For such purpose, we should take one step further and, first, arrange the collaboration among the existing projects; that is, to develop a network of circular economy projects which allows for a more comprehensive environmental and social impact. On the one hand, this would entail increased visibility for each company, which leads us on to the second point. To become a role model involves a consistent behavior in any and all business aspects. Therefore, if we talk about a circular economy system based on the principles of nature, coengagement is vital.

The fashion industry needs to be reasserted, giving a new meaning to getting dressed and restoring its own value, along with a recognition process, in order to coexist with a system and an industry that prove healthy for our lives. As discussed earlier, fashion is a social process and, as such, it deserves to become a tool to bond with, and feed on, the environment in a reciprocal relationship. The circular economy can offer an approach to sustainable development by fostering resource preservation, taking care of the environment and the society at large, and generating economic resources. Production and consumption processes (including all their related activities) need a new thinking pattern other than the current fast system.

1.7 Conclusion

The circular economy implementation right now is vital as it is a system that can slacken the accelerated pace of goods and services consumption. Reducing the pace involves permission to think things over and becoming aware of every action. Reducing the pace of production and resources requires changes in every part of the process. This, as well as its results, may take years to realize—which does not mean that it is either impossible or that the process is not worthwhile. Learning again to value resources and have a healthy interaction with our environment—when we were used to

doing just otherwise—is a great lesson that we need to learn. While our desire is that fashion really becomes a form of expression and identity, we should turn getting dressed into a conscious action. Consequently, making, buying, selling, educating, learning, using, and giving need to become conscious processes. The conscious action takes place in a context where human beings are regarded as such, treating their own kind fairly. This means to live in harmony with those surrounding us, respecting and even encouraging both our fellow humans and the future generations to express themselves freely, without forcing anyone or being forced. It is time to implement a holistic approach and thinking about how each part of the production process works to create better, from the design perspective, and to find alternative materials and processes. This is about looking for a new way to build and cooperate while passing on knowledge. The circular economy would be the guide in this learning process, which evolves as it is implemented and manages to change the context while continuously adjusting to it.

References

Anderson, R., 1998. Mid-course Correction. Chelsea Green. Junction.

Black, S., 2012. Worn Again: corporate upcycling and remanufacturing textile waste. In: Black, S. (Ed.), The Sustainable Fashion Handbook. Thames & Hudson, London, p. 259.

Departament of Labor, 2016. List of Goods Produced by Child Labor or Forced Labor. Required by the Trafficking Victims Protection Reauthorization Act of 2005. Bureau of International Labor Affairs, Washington.

Ellen MacArthur Foundation, 2012. Towards the Circular Economy - Economic and business rationale for accelerate transition. Ellen MacArthur Foundation.

Ellen MacArthur Foundation, 2017. A New Textiles Economy: redesigning fashion future. Ellen MacArthur Foundation.

Etzioni, Y., Neeman, Z., 2016. A sustainability textile design course as a transformative process. In: Earley, R., Goldsworthy, K. (Eds.), Circular Transitions 2016. University of the Arts London, London, pp. 338−348.

Fletcher, K., Grose, L., 2012. Gestionar la Sostenibilidad en la Moda. Diseñar para Cambiar. Blume, Barcelona.

Gullingsrud, A., Perkkins, L., 2015. Designing for the circular economy: cradle to Cradle® design. In: Hethorn, J., Ulasewicz, C. (Eds.), Sustainable Fashion What's Next? Bloomsbury, New York, pp. 292−312.

Han, S.L.C., et al., 2017. Determining effective sustainable fashion communication strategies. In: Heninger, C., Goworek, H., Panayiota, J., Ryding, D. (Eds.), Sustainability in Fashion. A Cradle to Upcycle Approach. Palgrave Macmillan, Cham, pp. 127−149.

Leonas, K.K., 2017. The use of recycle fibres in fashion and home products. In: Muthu, S.S. (Ed.), Textiles and Clothing Sustainability. Springer, Singapore, pp. 55−78.

Li-Chou Han, S., Hall, N., Apeagyei, P., Tyler, D., 2016. Whole systems thinking for circular economy practice. In: Earley, R., Goldsworthy, K. (Eds.), Circular Transitions 2016. University of the Arts London, pp. 349−365.

Mikerina, D., 2016. Re-thinking the place of semiotics in Fashion Studies. In: Urgelles Molina, A., et al. (Eds.), Fashion on the Move: Rethinking Design. Universidad de Navarra, Pamplona, pp. 31−39.

Niinimäki, K., 2017. Fashion in a circular economy. In: Heninger, C., Goworek, H., Panayiota, J., Ryding, D. (Eds.), Sustainability in Fashion. A Cradle to Upcycle Approach. Palgrave Macmillan, Cham, pp. 151−169.

Nudie Jeans, 2018. https://www.nudiejeans.com/productionguide/Visited 3 15.

Radhakrishnan, S., 2017. Denim recycling. In: Muthu, S.S. (Ed.), Textiles and Clothing Sustainability. Springer, Singapore, pp. 79−124.

Shaw, j, 2013. Fashion Africa. Jacaranda, London.

Twigger, A., 2016. Shifting perceptions: the Reknit revolution. In: Centre for Circular Design Circular Transitions. University of the Arts of London, London, pp. 57−67.

Vadicherla, T., et al., 2017. Fashion renovation via upcycling. In: Muthu, S.S. (Ed.), Textiles and Clothing Sustainability. Springer, Singapore, pp. 1−54.

Weetman, C., 2017. A Circular Economy Handbook for Business and Supply Chains. Kogan Page, London.

Wheeler, A., 2012. Textile recycling in the UK. In: Black, S. (Ed.), The Sustainable Fashion Handbook. Thames & Hudson, London.

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Circular fashion

2

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2.1 Introduction

2.1.1 The linear economy

Since the industrial revolution in the 18th century, the "linear economy model" has been the most accepted version of economic model. During the era of industrialization stages, raw materials were abundantly available for cheap prices, and the linear economy model was the model of business due to the developing technologies. In fact, this model manifested the growth of material production, employment, cities' development, living standard, profit, and also the demand for all goods. The fundamental principle of the linear model is provided in Fig. 2.1.

By this economic model, the companies extracted the raw material from the resources, converted them into products, and distributed them to the society. The customers of these products use them for a given time depending upon the product quality and type. Once the customer's need or the lifetime of the product ends, the product is disposed of as waste ultimately. The only possible way to discard the disposed wastes is through either landfill or incineration. In this model, the attempt of the product or waste to extract or to recover the useful raw material is merely absent.

At the beginning of 18th century, while the model started, the availability of the resources was plentiful and cheap than the cost of labor. Ultimately these factors motivated the manufactures to adopt the linear economy model, which used extensive raw materials, energy, and more profit with less capital and human labor. Since the manufacturing companies focused toward the higher profit, they ultimately neglected the process of recycling, reusing, and waste management methods. In support to that the government rules have also never emphasized the issues to the manufacturing companies and no protocols followed related to the recycle, reuse, and waste disposal methods.

Hence, the linear economy model is generally termed as "take-make-dispose" strategy. The hunger for raw materials is very high in this kind of economic model and still

Figure 2.1 The principle of linear economy.

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00002-9

continues. A research data reported by the Ellen MacArthur Foundation (Towards Circular Economy, 2013a), based on the research by Sustainable Europe Research Institute (SERI), states that,

> *As Estimated each year, the manufacturing of products in OECD countries consumes over 21 billion tonnes of materials that aren't physically incorporated into the products themselves (i.e., materials that never enter the economic system—such as overburden and parting materials from mining, by-catch from fishing, wood and agricultural harvesting losses, as well as soil excavation and dredged materials from construction activities).*

Furthermore, the report, quotes Eurostat (2011) data indicating,

> *a volume 65 billion tonnes of raw materials entered the global economic system in 2010—a figure expected to grow to about 82 billion tonnes in 2020, out of which 2.7 billion tonnes were dumped as waste, merely 40% of which was used again in any form (e.g., through recycling, reusing or composting). The unmanaged waste lost not only its original function, but it was also wasted as a source of energy.*

The major impact of the linear economic model on the society is material scarcity and negative environmental impacts. The examples of negative environmental impacts include climate change, destruction of natural habitats, and generation of waste, etc. The material wealth generated by the linear model was successful over the decades till the end of the 20th century. The professional data sources revealed that, in 1999, the commodity prices have met a critical inflation point due to the increase in the material cost. Along with the price increment in the 21st century, the increased demand also pushed the manufacturers to go for a huge quantity of production with cheap cost to meet the needs of their target customers, this eventually exerting a profit squeeze on firms and driving the value of total economic output down (McKinsey Commodity Price Index, 2013).

As of late, many organizations have started to see that this linear economy expands their risk in all aspects—most strikingly higher resource costs and supply disturbances. It is also to be noted that the price volatility level for metals, food, and nonfood agricultural materials are at a higher level than any single decade in the 20th century (Towards Circular Economy, 2013a). Global Footprint Network, an international research organization, is marking Earth Overshoot Day; it is the date when humanity's annual demand on nature exceeds what Earth can regenerate over the entire year (About Earth Overshoot Day, 2018). This year Earth Overshoot Day fell on August 2, 2017, which is earlier than the last year (September in 2016). In a research report they have mentioned that (World Footprint, 2018),

> *….. Humanity is currently using nature 1.7 times faster than ecosystems can regenerate. This is practically, akin to using 1.7 Earths*

The major flaw of the linear model is the depletion of raw material at some point times due to the ingenious way of utilizing it. As per the researcher's point of view, the material scarcity is already evident in the market in terms of volatile markets and raw material prices (Bocken et al., 2016; Towards Circular Economy, 2014; Limits of Linear Consumption, 2014).

2.1.2 Pitfalls of linear economy

- The increase in price volatility and growth of industries are basically connected with the raw material availability. Hence, in the linear economy the uncertainty about material availability grows
- The price volatility on the commodity increased significantly in recent time due to linear economy and developing risks in the market and makes investments in this sector as less attractive to the business people. This ultimately leads to long-term increase in raw material prices (Lee et al., 2012).
- The interconnectedness among the products is getting stronger in the current business situation. This subsequently leads to price fluctuation on different products due to connectedness (Towards Circular Economy, 2014; Lee et al., 2012).
- The increase in world population and the number of consumers with higher degree of material consumption also increased. The research reports by several agencies mentioned that the resource consumption in the world has doubled in the period of 1980−2020 and they had assured it will triple in the period up to 2050 if the linear business model continued (DEFRA, 2012; UNEP, 2011).
- The "take-make-dispose" strategy of the linear model increases the wastages in a large stream. This waste is left unused and overloads the ecosystem by hampering them from doing their essential roles.
- The major factor behind the increased material consumption is the short lifetime of the product. With this linear model, the service or life of the products makes the customer to look for new product frequently (Bocken et al., 2016; Accenture, 2014).

2.2 Circular economy

The foundation work for the innovative new concept circular economy was found several decades back in 1976 by "Stahel and Reday" (Stahel and Reday-Mulvey, 1976). They have detailed the concept of "circular economy" or "an economy of loops" in their work, which is related to the life extensions of products and their ecology behind the process. In 1982, a paper submitted by Stahel on the title of "The product life factor" explains the fundamental core concepts of circular economy principles (Stahel, 1981). In his paper he defined the circular economy as,

> *The extension of the use-life of goods is, first, a sensible point at which to start a gradual transition towards a sustainable society in which progress is made consistent with the world's finite resource base and, second, a strategy consistent with an active and independent role for the private sector. Product-life, or the period over which products and goods are used, governs their replacement speed and thus the*

> *consumption of natural resources required for their manufacture and the amount of waste they create. Shortening product-life increases demand for replacement goods where these can be afforded. Extending product-life optimizes the total life-span of goods and reduces depletion of natural resources and consequently waste; it builds on and increases wealth. A longer use of products will thus contribute to the transition towards a sustainable society*

The reuse of product and recycling of product are the waste reduction and resource conservation strategies majorly recommended by Stahel for industrial production. The two circular economy concepts detailed by Stahel are (1) product specific and (2) material specific. The first concept basically focused on product reuse and life extension and the second concept is based on a material-specific loop focused on post used waste and resources (Stahel, 1994).

In his theory, as in Fig. 2.2, Stahel mentions four loops, namely, reuse loop (1), repair loop (2), reconditioning loop (3), and recycling loop (4), where, reconditioning means the author mentions the use of used product as a raw material for a new one. By this principle, the life span of the goods and products extended with the available resources and without consuming extra. Financial and resource management is now aimed at reducing total long-term utilization costs. Stahel also mentioned that,

> *The effectiveness of this spiral-loop system is greatly enhanced by a built-in inertia which keeps the loops as small as possible: do not recondition something that can be repaired, do not recycle a product that can be reconditioned economically. This inertia can in turn be applied to components, products and systems themselves, i.e., replace or treat the smallest possible unit only (Product-Life Factor (Mitchell Prize Winning Paper, 1982)).*

Chemist Michael Braungart and architect William McDonough are the other scientists who contributed significantly in framing the concept of circular economy

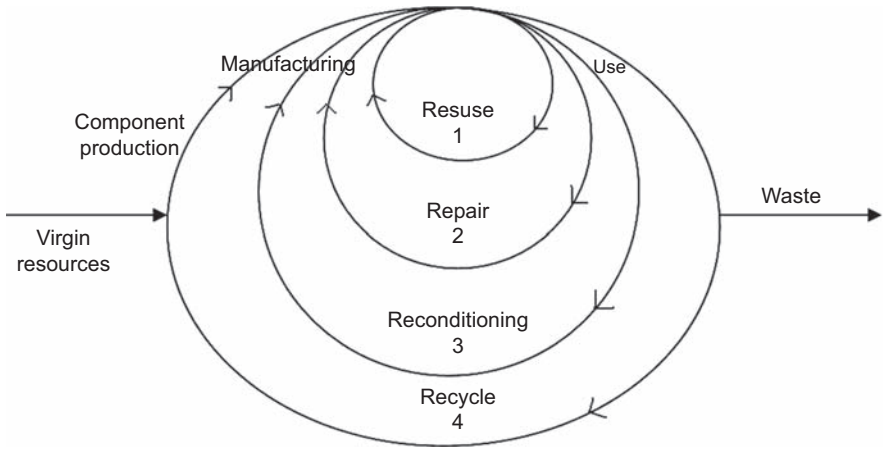

Figure 2.2 Stahel's spiral loop system that minimizes matter, energy flow, and environmental impact (Stahel, 1981).

(McDonough and Braungart, 2013). They have developed The Hannover Principle called "design for sustainability" in 1992, in connection with the World's Fair Expo 2000, which encourages designers to apply sustainable elements in their design so the product end life will not be a problem. Braungart and McDonough have also published books on "Cradle to Cradle: Remaking the Way We Make Things" and "The Upcycle," respectively, in the years 2002 and 2013. The books provide a clear understanding of the linear economic model and their research also proposed a cradle to cradle (C2C) design model for designers (McDonough, 2002). They have mentioned the vision of circular economy is that once a product reached its end of life situation it either should become a "biological nutrient" or "technical nutrient." This model differentiates the technical and biological pathway of the products (Fig. 2.3). In the biological cycle, the consumption is high and the substances are designed to back-feed into the system by different processes like composting and anaerobic digestion. These cycles regenerate living systems, such as soil, which provide renewable resources for the economy. The technical pathway recovers and restores products, components, and materials through strategies like reuse, repair, remanufacture, or recycling (Kerli Kant, 2016).

The circular economy concept is much broader than that of a simple waste administration process as stated by Ghisellini et al. (2016). They have mentioned that

> *… it requires a broader and much more comprehensive look at the design of radically alternative solutions, over the entire life cycle of any process as well as at the interaction between the process and the environment and the economy in which it is embedded, so that the regeneration is not only material or energy recovery but instead becomes an improvement of the entire living and economic model compared to previous business-as-usual economy and resource management.*

The concept of circular economy has direct connection with the sustainable development concept. It requires a balanced coordination with the economic, environmental, technological, and social aspects of a process. It also provides interaction among these aspects (Ghisellini et al., 2016; Zhijun and Nailing, 2007).

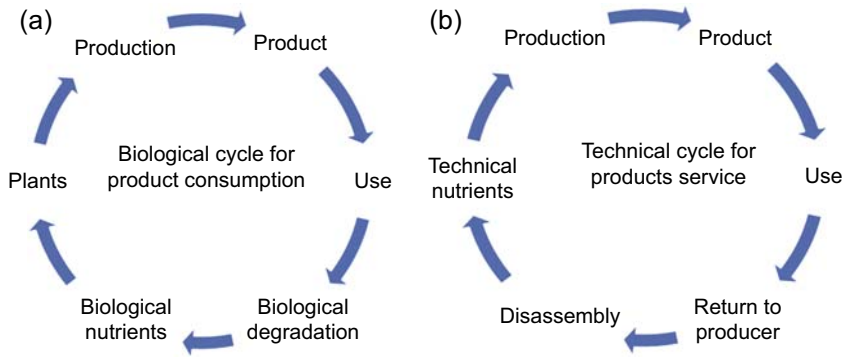

Figure 2.3 (a) Biological cycle for products for consumption and (b) technical cycle for products for services.

2.2.1 Concepts of circular economy

The most prominent and accepted definition for circular economy was provided by the Ellen MacArthur Foundation, which reads (Towards Circular Economy, 2013a):

> *Circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.*

Technically the concept of circular economy is driven by three principles (Towards Circular Economy, 2013a).

Principle 1: Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows—for example, replacing fossil fuels with renewable energy or using the maximum sustainable yield method to preserve fish stocks.

Principle 2: Optimize resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycles—for example, sharing or looping products and extending product use cycles.

Principle 3: Foster system effectiveness by revealing and designing out negative externalities, such as water, air, soil, and noise pollution; climate change; toxins; congestion; and negative health effects related to resource use.

The concept of circular economy was depicted in Fig. 2.4. The typical linear production process was depicted in the central axis of the diagram. The axis represents the linear design production, consumption, and also the waste as in a single flow. The marked arrows around the center axis represents the possibilities for circularity of the product with respect to reuse, recycling, or upcycling of resources, residual waste, and other materials and products. The figure thus represents the conversion of a linear system into a circular economy system, where some biological or technical materials are used as input to convert them into products. The main focus of the circular economy is to remove the last stage of the linear economy system (waste) completely from the process. The circular economy principle not only describes the process of the principle but also outlines the economic values of the potential resources (Eva Guldmann Best Practice Examples of Circular Business Models, 2016; Towards Circular Economy, 2013a,b). The Ellen MacArthur Foundation depicts four aspects for circular value creation process (Towards Circular Economy, 2013a).

2.2.1.1 Power of the inner circle

- Tightens the circle, meaning that the innermost circles will provide large savings in terms of material, labor, energy, and capital.
- Reduces the environmental impacts in terms of GHG emissions, toxic substances, etc.
- Provides comparatively high-quality virgin material.
- The cost of gathering, recycling, and using in production or as a component is lower than the linear economy, making the setting up of a circular system a viable option.

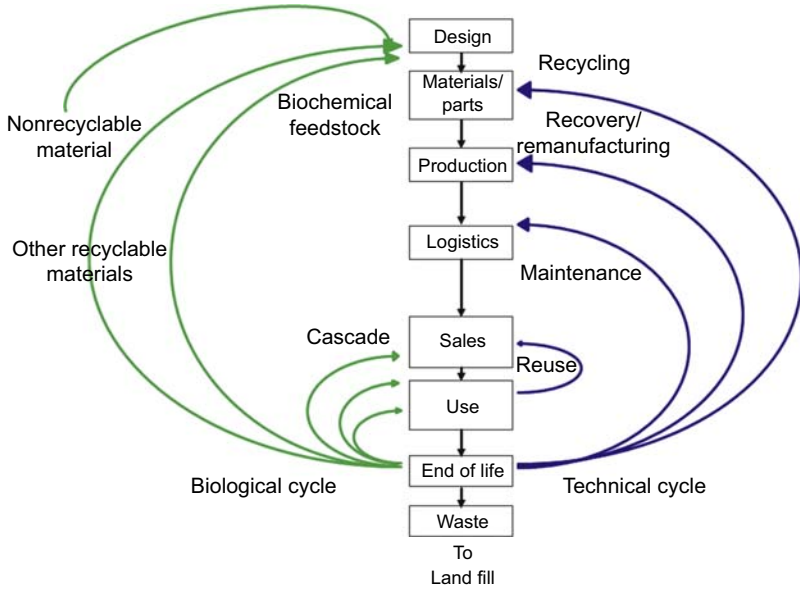

Figure 2.4 Concept of circular economy principle (Eva Guldmann Best Practice Examples of Circular Business Models, 2016).

2.2.1.2 Power of circling longer

- It keeps the product or material in use for a longer time than the linear system.
- Longer time in the circle can be achieved either by a more consecutive cycle or by spending longer time in the same cycle.
- An increment in the circle time reduces the customer needs and so substitutes the pure raw material inflow to counter the rakishness of the material out of the circle.
- The increase in the pure raw material cost and other resources makes this level an attractive one.

2.2.1.3 Power of cascaded use

- This system enlightens the opportunity of the products or materials to be converted into a new product, technically downcycling.
- A simple example is converting the cotton-based clothing materials into filling materials for cushions and then as insulating material in various application.
- This process reuses recycled material as a substitute for pure raw material, reducing the inflow of pure resources and thus the value developed for the recycled material.

2.2.1.4 Power of recyclable designs

- To develop a higher value to the product, the purity of the raw material used in the production process is an important factor. Currently most of the recyclable materials are of a mixture of two different sources. This is due to either by their design or because they are collected without considering the purity of different materials.

- Proper designing of the product by considering the circular economy will lead to the easy separation of raw materials and better identification of embedded components and different material mixtures.
- This also reduces the damage of resources in the recycling operations like collection, handling, separation, transportation and also reduces the material contamination after collection.
- The abovementioned factors reduce the cost of recycling process and also improve the quality of the product throughout the cycle time.
- Removal of toxic materials in the manufacturing cycle is another important factor to reduce the risk, which should be incorporated in the design level itself

The basic principles of the circular economy are provided in Table 2.1 for better understanding (Hans Stegeman, 2015; Towards Circular Economy, 2013a,b, 2014).

There are other different concepts also added to the literature in the past years, which are very similar to the circular economy or inspired by circular economy principles. Frosch and Gallopoulos explained the concept of industrial ecology, which is very closely related to the concept of circular economy (Frosch and Gallopoulos, 1989). The concept is,

> *the traditional model of industrial activity − in which individual manufacturing processes take in raw materials and generate products to be sold, plus waste to be disposed of − should be transformed into a more integrated model: an industrial ecosystem. The industrial ecosystem would function as an analogue of biological ecosystems.*

The few other similar concepts related to circular economy principle are circulation economics (Ingebrigtsen and Jakobsen, 2006), supply loops (Geyer and Jackson, 2004), and product−service system (Mont, 2002). Out of all the other similar concepts, the product−service system concept is widely accepted in the industry due to its effectiveness in sustainable production and consumption (Kerli Kant, 2016). The product−service-system mainly aimed toward the services like repairs, lease of product, and other value-added services. Researcher Mont defines the product−service system as (Mont, 2002)

> *A system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy customer's needs and have a lower environmental impact than traditional business models.*

The main objective of the product−service system is to reduce the environmental impact to the minimal possible level by closing the material cycle or by reducing the utilization of materials through alternative materials and ultimately to increase the overall productivity. In this way, the product−service system directly supports the circular economy principle. In the course of the last late years some product−service system business models have entered the market that focus on fashion and garments; in any case, they appear to stay small-scale with challenges extending to the standard market (Pedersen and Netter, 2008).

Table 2.1 Principles of circular economy

Principle	Description
Design for reuse	If the technical and biological products are created or designed for reuse again in a new cycle, the waste will not exist in the product life cycle. In other words, the material can be reassembled and reused. Thus, the value of the product will be extended wherever possible or upcycled. This ultimately would benefit prosperity in terms of new services, new product combinations, lower environmental impact, and toxicity.
Resilience through diversity	The business or system or economy should be resilient in terms of unexpected external influences. Meaning that, the practical business strategy should be heterogeneous. The business models and network should have enough diversity with sufficient mutual connections along with alternative suppliers of resources and end-users like the natural eco-system
Energy use from infinite sources	During the upcycling process, the additional energy should be renewable. The circular economy mainly focuses on renewable energy but not on the labor.
System thinking	This principle mainly focuses on the nonlinear system, in which the backfeed loops play a vital role. This requires a long time focus at various levels of the production system. At different scales of industry, the dependencies, systems influence, and feedback loops contribute to the resilience of the circular economy.
Bio-based basis	Goods for consumption are increasingly made from biological materials. The "cascading" principle applies in their use: nutrients are used for various purposes before they return to the biosphere circuits.

Even though the basic idea of the circular economy and the related benefits were outlined decades ago, the recognition of the concept was not so fast. But in the recent time, the concept gained momentum in different sectors like the academic research, politics, and business prospective. A research by Kirchherr et al. revealed that the academic research on the circular economy concept gained its acceleration in the past 2 years (Kirchherr et al., 2017). The researchers have consolidated major research works and mentioned that more than 100 articles were published on the topic in 2016, compared to only about 30 articles in 2014 (Geissdoerfer et al., 2017). In the same manner, the global level consultancy firms also started to publish their research works recently on this area to exhibit their expertise in the area of circular economy (Kipping and Clark, 2012). For example, the leading consultancies like, Accenture,

Deloitte, EY, and McKinsey & Company all have published research reports on circular economy in the past 2 years (Gartner, 2015; Hannon et al., 2016; Hestin et al., 2016; Lacy et al., 2015; EY, 2015)

In case of government policy implementation, there are few initiatives by the European Union. In 2008, the waste directive of the EU implemented two laws namely, "polluter pays principle" and "extended producer responsibility." One other flagship initiative by the European government is "A Roadmap for a Resource-Efficient Europe," which aimed toward a resource-efficient Europe under the Europe 2020 strategy (Kerli Kant, 2016). This amendment supports sustainable growth by a resource-efficient and low carbon economy strategy. The European Commission adapted a zero waste program, building up a legitimate system for an EU-wide circular economy. As per the Commission, the system will help reusing and keep the loss of important materials; make employments, monetary development, and new plans of action; and decrease ozone-harming substance discharges. The major goal of the initiatives are to recycle and reuse 70% of municipal waste and 80% of packaging materials by 2030 (Braw, 2014).

The Commission evaluates that the circular economy can spare EU organizations 600 billion Euros. Ahead of all the initiatives, countries like the Netherlands, Sweden, Denmark, and Scotland already adapted the circular economy principle and were moving toward sustainability (Braw, 2014). China is one of the countries which promoted circular economy from early 2002. China implemented the circular economy because of the natural harm and resource consumption that was happening from experiencing its industrialization procedure. China is additionally dynamic in creating arrangement wants for setting up greater sustainability practices and monetary development in future decades, with focus for the year 2020 (Circular Economy Promotion, 2008).

However, the main requirement of the circular economy concept is for more initiators, those can adapt the concept. As the circular economy concept is complex in nature, the implementation part requires heavy support from the allied sectors of the manufacturing industry like designers and business providers like services and materials. The most complex part of the circular economy is the requirement of significant changes from the manufacturers in terms of practices, policies, and decision-making tools. Increasingly, the business community around the world has become aware of the circular economy and recognized the potential business case for improving resource productivity. A research by Mayer depicted that in 2030, the required resource input for production will reduce around 17%−24% due to the improved efficiencies throughout the value chain (Meyer, 2012). If the circular economy concepts are adapted properly in the industries of European countries, it contributes significant material cost saving in industries, thus the EU GDP will boost up by 3.9%, as reported by the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2012). Companies across several industries have started to capture these opportunities by introducing new business models that focus on resource efficiency, services that offer functionality rather than ownership and closing the loop of products.

2.3 Circular fashion

The concept of circular economy is the inspiration for the circular fashion initiative. In 2014, the term circular fashion was coined by two individuals at different occasions. The first one is Dr. Anna Brismar, owner of a Swedish consultancy firm "green Strategy." The other person who termed the phrase "circular fashion" is one of the H&M staff at Stockholm. They first used the term officially in a presentation at the event "Almedalen week" in the south of Sweden. Dr. Brismar introduced the first definition and principles of circular fashion in a theoretical basis in 2014. She detailed the concept of circular fashion in a Fashion Show and Talk event at central Stockholm, as guidance for involved brands in the fashion show as well as for individuals (Origin of the Concept Circular Fashion, 2015). 2014 was the year the concept of circular economy emerged and sailed strongly on a political agenda in Sweden and Europe.

2.3.1 Definition of circular fashion

The main principles of circular fashion are based on circular economy and sustainable development. This principle relates the circular economy concept to the fashion industry in a large manner, like apparel, sportswear, outdoor wear, garment, and accessories. The definition of circular fashion is derived from the framework of the Ellen MacArthur foundation by Dr. Brismar as (Origin of the Concept Circular Fashion, 2015),

> *Circular fashion can be defined as clothes, shoes or accessories that are designed, sourced, produced and provided with the intention to be used and circulate responsibly and effectively in society for as long as possible in their most valuable form, and hereafter return safely to the biosphere when no longer of human use*

In simple words, the definition of the circular economy urges the following points:

- The apparel and fashion products must be designed for prolonged existence, resource effectiveness, nontoxicity, biodegradability, reprocess and reusability, and good morals in mind
- The textile and fashion products should be procured and produced with preferences given to local resources that should be biodegradable, nontoxic, and recyclable. Furthermore, the manufacturing and sourcing process should be efficient, ethical, and safe.
- The circular fashion concept further urges that the products should be used for as long as possible through good maintenance, care, repair, and renovation. Sharing of the product with multiple users over the life span of the product was also encouraged.
- The principle further enforces that the product must be redesigned or altered into a different product to give a new application or usage or a new life to that resource or material. And finally the possible materials and components of the product should be recycled and reused for the production of another new item.
- If the content of the product is unfit for the recycling, the material should be composted to become nutrients for plants and other living organisms in the ecosystem. In consolidation, the total life cycle of the product should be eco-friendly and should contribute the positive well-being of humans, ecosystem, and society.

2.3.2 Basic principles of circular fashion

The "Green Strategy" firm outlined 16 principles specifically for the circular fashion concepts, which again derived from the concepts of circular economy and are (Sixteen Principles for a Circular Fashion Industry, 2015) depicted in Fig. 2.5.

2.3.3 Fashion industry and consumption

World clothing and fashion industry is the most dynamic and fast-moving industry. Clothing is one of the massively underutilized products in the world. The research reports confirmed that the utilization of clothing items increased rapidly in recent years. The usage life of the garment or clothing significantly reduced 36% compared to the last 15 years (Circular Fibres, 2016a). Even low-income countries also have a high clothing utilization percentage in recent years. In China alone the utilization time of clothing items reduced by 70% and in the United States, they use the clothing only one-fourth of a time of global average (Ellen MacArthur Foundation, 2017). The value of the apparel market has raised by 5.5% in 2016 than the previous year with a value of 842.7 billion USD. The Asia-Pacific countries alone accounted for 60.7% of the global textile mills market value in the same year. It is forecasted to reach 1004.6 billion USD in 2021 with a growth of 19.2% from 2016. Similarly, the growth of the retail sector also noted around 4.8% than the previous year in 2015, with a value of 1254 billion USD. The expected growth of the retail sector is 31.8% in 2020. Out of the total retail value, the Asia-Pacific region accounted for 36.8% (Lu, 2017). A survey conducted by

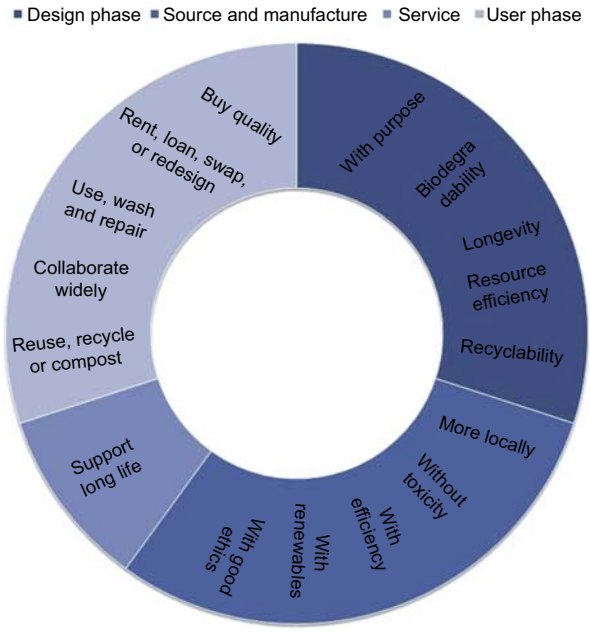

Figure 2.5 Principles of circular fashion.

Market Line, a business information company, depicted that, since 2011, the global apparel industry grew at a rate of 4.78% yearly and the value of sales is around 1.4 trillion USD for 2017. The research also projected a growth of 5.91% for the next 3 years for the apparel industry sector as in Fig. 2.6. They had also mentioned that at 2020, the market size will reach a value of 1.65 trillion USD worldwide (Ganit, 2016).

As per the Apparel Export Promotion Council (AEPC) 2016–17 annual report, the total export in India hiked a growth of 5.4%. In rupee terms, export for the period of 2016–17 was Rs. 117,202.4 Cr. as against Rs. 111,182.8 Cr. of the same period of the previous financial year. The increase in the apparel product manufacturing is not only by the impact of the fast fashion trend but also by government policies and norms. The industry has witnessed a spurt in investment during the last 5 years. During the period of 2000 to March 2017, the industry attracted a worth of US$ 2.47 billion as foreign direct investment (Ministry of Textiles, 2017)

2.3.4 Fast fashion trend and environmental impact

Fast fashion is a linear economy system, which motivates the customers to buy more clothes because they are affordable but discard these after only one season. The fundamental concept behind the fast fashion strategy is consumption, fast-changing trends, and low quality, which leads the consumers to change their preference more frequently. Globally each year, millions of garments end up in a landfill. Annually, the customer wastes around 460 billion worth of clothes approximately as waste around the globe (Circular Fibres, 2016b). Research studies revealed that some of the wasted garments were discarded after just 10 uses. A research performed by the Ellen MacArthur Foundation mentioned that, in the last 15 years, the clothing sales increased double the time from 50 billion units in 2000 to more than 100 billion units in 2015. At the same time they have also mentioned that worldwide the utilization percentage of clothing material reduced significantly than that of the previous years.

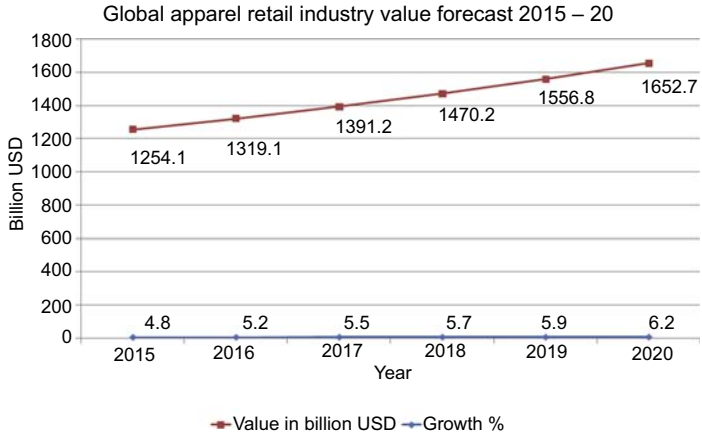

Figure 2.6 Global apparel retail industry value forecast 2015–20 in $ billion (Lu, 2017).

Fig. 2.7 represents the clothing utilization study results of previous years' research (Ellen MacArthur Foundation, 2017).

The most important reason for the reduced utilization in the clothing material is mainly because of the fast-changing trend. This increased consumption and reduced utilization percentage per human are the negative outputs of the linear system. To provide an enhanced perspective, the World Bank claims that the average GDP growth rate around the globe is 2.7%, but the market line survey predicts that the consumption of the clothing is 4.5%, meaning that with the average growth of 2.7, global income consumers spend double the time on the purchase of clothing (Ganit, 2016).

> *My grandmother has only one shirt in her wardrobe. My mother has three. My daughter's generation, 50. And 48% of them, she never wears.*
>
> *Jack Ma, Founder and Executive Chairman of Alibaba Group.*

The major problem noted out of the fast fashion system is environmental issues. The fast fashion strategy promotes cheap and less quality materials with a short life time. Ultimately these fabrics are produced with synthetic fibers. The use of synthetic fibers in fast fashion is very huge compared to cotton. Higher utilization of synthetic fiber leads to higher environmental impact. In case of polyester, the process sequence releases almost three times more carbon dioxide to the environment than cotton. Polyester is one of the major synthetic fibers present in almost all fast fashion items and represents 60% of the total clothing used. The deposits of polyester in the landfill spoils the environment further (Gina-Marie, 2016). It takes decades to degrade. In 2017, around 21.3 million tonnes of polyesters were used in clothing production, which is approximately 157% higher than that in the year 2000 (Gina-Marie, 2016).

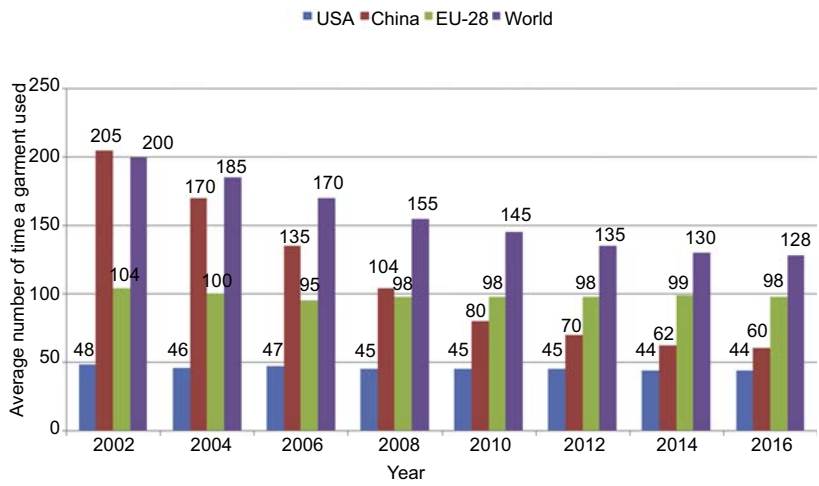

Figure 2.7 Clothing utilization trend, including reuse within the regions (Ellen MacArthur Foundation, 2017).

As the production of polyester includes fossil fuel, the carbon footprint of polyester increases multiple times than that of cotton clothing. The fast fashion trends introduced into the market by brands like Zara, H&M, etc. have expanded their manufacturing in a huge manner and have become the biggest apparel manufacturers in the world market. The promotion of fast fashion brands "leads to increased consumption of all clothes, including budget and basic items." As such, the life cycles of consumer products are shortened by 50%, from 1992 to 2002 (Gina-Marie, 2016). The fast fashion industry consumes mostly nonrenewable resources, approximately a 98 million tonnes in total per year. This list includes the resources like oil to produce synthetic fibers, fertilizers to grow cotton, and chemicals to produce dye and finish fibers and textiles (Watson et al., 2016).

Out of these materials used, 73% are lost after the final garment use, 10% during the production, and 2% to the landfills from manufacturers, and these quantities do not even reach the market (Ellen MacArthur Foundation, 2017). Overall, one truckful of clothing and textile materials are landfilled or incinerated every second (Ellen MacArthur Foundation, 2017). All the textile and clothing production processes are highly water intensive, starting from the farming process; it consumes around 93 billion cubic meters of water annually from the production phase to the user phase. The current wasteful, linear system is the root cause of this massive and ever-expanding pressure on resources. The total greenhouse gas emission from the apparel and textile industry is around 1.2 billion tonnes, which is more than the total of all international flight and maritime shipping emission (International Energy Agency, 2016; Circular Fibres, 2016a,b). The textile industry plays a vital role in the water pollution globally. Out of total industrial water pollution, 20% of water is polluted by the textile industry like dyeing and finishing of textiles. Apart from this, the textile industry is also the main contributor to the plastic entry to the aqua system. Every year, the industry disposes around a half million tonnes of plastic microfibers like polyester, nylon, and acrylic (Kant, 2012; O'Connor, 2017).

It is also estimated that the resource consumption of the textile industry will increase multiple times in the next few decades. The CO_2 emission will increase by 26% in 2050 from 2% in 2015. The expected microfiber disposal in the ocean will be around 22 million tonnes from 2015 to 2050. As an overall, the negative impacts of the textiles industry are set to drastically increase by 2050 (Ellen MacArthur Foundation, 2017; Circular Fibres, 2016a,b; Leonard, 2016). Levi Strauss & Co. conducted the apparel industry's first life cycle assessment study in 2007 to assess the entire life cycle impact of a core set of products. They had analyzed the impact of a pair of jeans on the environment in terms of water consumption and CO_2 emission. The important factor of this study is that they had conducted the study from the farm to end of product life with the customer. Their findings showed that with respect to water consumption, a pair of jean consumes approximately 3772 L of water in its total life cycle. Out of that, around 68% of water is used in the fiber production stage and 23% of water consumed at customer use. In the case of the CO_2 emission, the impact is very high in the area of customer use. Out of 33.4 kg of total emission, a maximum of 12.5 kg of CO_2 is emitted at the customer use phase. The second highest emission is at fabric production stage, which releases around 9 kg (The Life Cycle of a Jean, 2016).

2.3.5 Readymade society—impacts

In this culture, the production is basically focused toward increased economic profits and attainment of maximum sales. The products are not specifically manufactured for the requirements of the customer, instead they are predesigned and premanufactured based on a forecast done on the sector. The customers need to adjust their preferences in the readymade society. The circular fashion initiators defines the readymade society (The Problems of Our Ready-Made Society, 2017) as

> *A 'ready-made society' here refers to a society in which consumer products (such as clothing, shoes, accessories, home textiles, furniture, IT-devices, home appliances and other consumables) are designed and manufactured − often in large volumes and similar varieties − based merely on trend forecasts, estimated sales and expected consumer behaviour.*
>
> *Anna Brismar, Green strategy.*

The readymade market/society appears, like the consumer's influence on the manufacturing, to be very minimal, in terms of buying a wrong, or too much of, product. Basically this is due to the fact that they are not involved in the design and development part. However, it is the fact that the readymade product production is generally forecasted from the consumer behavior and purchase number in the previous season or year. "Planned Obsolescence" is the fundamental concept of readymade product manufacturing companies. By this strategy, the products are designed and manufactured to live a very short life span. This may be by any means like, low quality raw material, which is intentionally used to reduce the product life for products like apparels; outdated styles, meaning that the products in the market will be replaced intentionally by a new style; and the old product manufactured in such a way that it will be obsolete in a short time, for example, electronic gadgets. These kind of strategies create endless demand in the market at the same time consuming lots on nonrenewal resources and letting out more amounts of toxic substance into the environment during manufacturing (The Problems of Our Ready-Made Society, 2017).

Especially in the case of apparel product, the companies like fast fashion market frontiers increased their product line in a huge manner. Previously the apparel companies were producing only two seasons in a year but due to this fast fashion trend and consumers' increased purchase behaviors in the readymade market, they are forced to work with more number of styles with cheap cost. Currently, these brands are producing 12 collections in a year. Meaning that, every month they are launching a new style. This makes the purchased apparels an outdated one within a month and the consumers are forced to go for a new style by leaving the old dress materials useless.

2.3.6 How to close the loop?

In any manufacturing process, a closed loop system is a system where products and their components are designed, manufactured, used, and handled so as to circulate within the society as long as possible with maximum usage and less or no

environmental effect. To obtain the abovementioned need, all the manufactured products must contain the following requirements. The inclusion of these preconditions will make the manufactured materials a sustainable one with long life ("Closing the Loop" in the Fashion Industry, 2013).

- **Product design**—Should allow the users to disassemble the individual components to repair or renew its part and it should also allow the user to recycle the components completely at the end of life wither by a technical cycle—conversion into other components by recycling or by biological cycle material should degrade as biological nutrients.
- **Production**—The production process of any product should be of safe and should not utilize any harmful chemicals or processes in manufacturing stages and so it ensures a safe recycling process in terms of human, animals, and ecosystems.
- **Recycling**—There should be a predefined mechanism and technology, where all the end of life products like clothing will be collected, sorted, and recycled based on the quality. This reduces the impact significantly. In this process, the contribution and involvement of the consumer is also important.
- **Product repair and reuse mechanism**—There should be a proper mechanism in the society to repair the product or redesign it to another purpose to extend its life time. In the case of secondhand materials, proper procedures need to be fixed in relation to the collection, sorting, selling, and recycling activities

2.4 Economy systems to encourage circular fashion

2.4.1 Rental economy models

The research reports by the Ellen MacArthur Foundation stated different rental-based models for customers to increase the life time of the product (Towards Circular Economy, 2013b). They had mentioned that the models are inspired by "Netflix," an online movie rental system (Fig. 2.8). This clothing rental model provides the needed styles for the particular customer, where the need for the new clothing is decreased comparatively. These models are very valuable when considered for the segment of clothing which is used for the short time needs like maternity wear, fashion preferences, day-to-day requirements, luxury clothing, etc.

The data collected from the United Kingdom suggest that there are a lot of scope for these rental models as shown in Fig. 2.9. This study revealed that 26% of disposals are due to the owner not liking the clothing anymore. Another 42% are disposed due to fitting issues with the owner. The proposed rental models will address the issues with the two sections of customers. Furthermore, the research identified that a particular percentage of the clothing were used only for special occasions. (WRAP, 2016).

1. **Monthly rental subscriptions model**

   This model allows the customer a variety of styles on a predefined monthly rental fee. The customer can pay the fee to the retailer and rent the particular number of garments for a defined period of time. The time and number of garments can be defined based on the various influencing factors like type of clothing, season, etc. This model is valuable for the customers who prefer to change their outfit frequently or based on the fast-changing fashion. This also provides a viable business option for retailers (Ellen MacArthur Foundation, 2017).

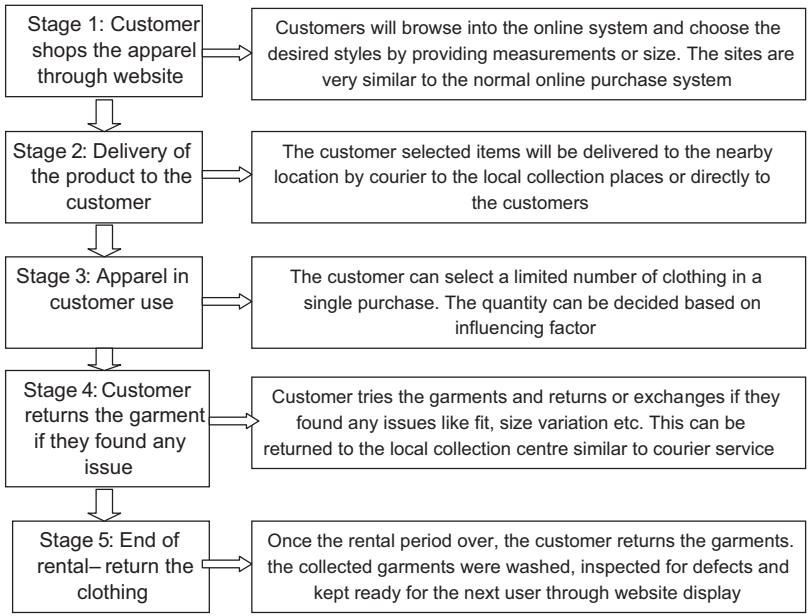

Figure 2.8 Clothing rental model inspired by Netflix.

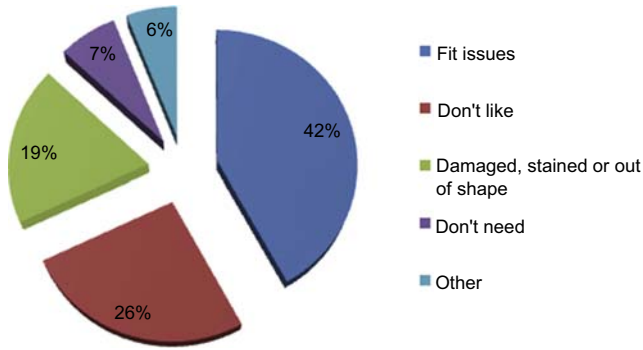

Figure 2.9 Reasons for disposal/donation/sale of clothing in the United Kingdom.

This is not a new idea totally; this model was already in business with brands such as Le Tote, Gwynnie Bee, Kleiderei, Vigga, and YCloset. The Chinese brand "YCloset" secured an investment of 20 million USD in 2017 alone (Shwe Gaung, 2017). This shows the potentiality of the business in this sector. Another brand, which is pioneer in this model, is "rent the runway." They initially started with short-term rental service, but they also changed their business model to monthly rental in 2016 (Cision, 2016). This kind of model also exists in the market for one time or short life clothing like maternity wear and infant and baby clothing. In these models, ownership of clothing is retained by the retailer, who redistributes clothing that no longer fits, after rigorous quality checks and cleaning procedures. This system provides the following advantages:

- Long-lasting customer relationship and in turn provides consistent business
- Direct access to the customers' feedbacks about their needs
- Customer will be benefitted in a huge manner by accessing a variety of clothing choice
- It reduces unnecessary purchase and reduces the quantity of unused clothes in wardrobes

2. **Short-term rental model**

   In this rental model, the methodology works similarly to the previous one, but the company offers only short-term rental service for needs like special occasion dresses, luxury clothing, function wear, and costumes. This service provides affordable access to high-quality clothes and also an opportunity to multiple users to use this. In this way the life of the product is extended for a long time and the clothes will not be kept in the wardrobe without use. Here also, the retailers will be the owner of the garments. The customers are expected to return the clothing after the occasion use immediately (Ellen MacArthur Foundation, 2017).

   The Internet and online concepts really boosted this kind of service model due to widespread accessibility. The successful example of this model is Rent the Runway; from the United States, they have rented more than USD 800 million in retail value of clothing in 2014 alone (Vasan, 2015). Another brand in this segment is Houdini Sportswear, who started their operation from 2013, renting outdoor sports shells and providing high-quality performance sportswear for one weekend or a week at affordable prices to every segment of people. The reason behind their success is they rent the sportswear at around 10%−25% of its retail price (Rent Shell Layers and Minimize your Environmental Impact, 2018).

3. **Sale of durable clothes model**

   The customers usually respect high-quality and durable clothes. But the issue with the market is the customer could not find out information about the durability. This lack of information misleads the customer to different products, even the particular one that meets the desire of the customer. For segments like nonseasonal items, formal wear, work wear, uniforms, functional clothing, and inner wear this kind of durable garments are advisable. The customers usually throw this kind of nonseasonal wears once they have a flaw in the material. Like color fading, nonremovable stains, or other factors. If the material is durable then there is no doubt about the consumer usage time. If a particular brand has proved its durability, in some cases this may be a key factor to selling their product in the market. Improving durability has broad business advantages for brands, such as reducing the risk of damaged and returned garments, enhancing competitiveness, safeguarding reputations, and increasing customer satisfaction and brand loyalty (Nnimki and Hassi, 2011).

2.4.2 Resale or reuse model

Resale of the clothes is the best option to increase the life time of the product. As the durability of the product increases, the possibilities for the reuse and resale increases. This process is already in the world in the form of charity shops and online resales. However, the opportunity for everyone in different regions of the world is very less. To increase the possibilities of reuse and resale, the preowned clothes should be more attractive to the consumers and also affordable with latest fashion features. By putting customer experience first and making resale models convenient and accessible, resale could become a new norm. Similar to the new clothes, the strategies should be brought in to display the quality and hygiene of the renewed clothing. This makes the customers to understand the standard and this could increase the possibilities of preused clothing sales.

Reuse—This can either take the form of primary reuse, which is reuse for the same purpose, or secondary reuse, which is reuse for some purpose other than that originally intended. Reuse brings ample benefits to the environment and remains a highly preferred option, since it does not demand any resources or emit any pollutants in order to provide that benefit, so there is no associated impact. Out of the two mentioned options, the primary reuse is preferred in this model, since it will not lower the value of the product and also makes the product in use for a longer time than any other option. The proposed model for the reuse is clothing swap, which is, in its basic form, a meeting or party where people get together to swap clothing, accessories, and the like, all for the sake of getting rid of the articles they will not use—and giving it a new life with someone else—and then gaining some great new articles for the individual, too. The notion of swapping is not a new concept, however; many groups and organizations exist that hold clothing swaps, in a variety of sizes, to raise money and clothes for charitable donations (Anonyms, 2013). The best option to extend the life of the product with the same quality is clothes swapping or buying secondhand. Most people probably have a few items they have never worn or pieces that no longer reflect their style but are still in great condition. So, instead of throwing away what is bogging down their closet, landfills can be spared, the environment helped, and money saved by giving their clothes a second life (Sarah McInerney Swap till your fashion footprint drops, 2009).

2.4.3 Recycle models

One of the important ways of making the apparel and textile product sustainable is extending its life by a recycling process. It is a well-known method for centuries; however, due to technological issues, quality, and cost associated with that process, it has not been implemented properly. The circular economy report by the Ellen MacArthur Foundation stated that (Ellen MacArthur Foundation, 2017)

> *Currently, less than 1% of textiles produced for clothing is recycled into new clothes, 87% of material used for clothing production is land filled or incinerated after its final use representing a lost opportunity of more than USD 100 billion annually and high costs for land filling and incineration. This is a significant opportunity, even if the industry could only capture part of it. Using recycled rather than virgin materials also offers an opportunity to drastically reduce non-renewable resource inputs and the negative impacts of the industry.*

The real issue with the current recycling system is most of the materials are cascaded to lower value applications like cleaning cloths, insulation material, and stuffing items. This process extends the life of the product but still only in a short period of the time. Hence, it is proposed to recycle the material equal to the same quality or at the possible high quality. The practical issues associated with this process are the blended fabric and lack of proper information about the blends. Hence, the material must be designed in such a way by considering the future recycling activity. This will generate the recycled resources in a similar quality of the virgin material. The

technology related to the separation and sorting out of the clothes is also to be implemented properly to separate the clothing based on the required criteria (Fletcher, 2014).

2.5 Barriers for circular fashion

Similar to any other initiative, the circular fashion initiative also has a few importance barriers which need to be addressed appropriately. The intention of the circular system is to extend the life of the apparels as long as possible in a different manner like the recycle, reuse, and reduce concept. The majority of the issues arise with the recycling concept. The basic issues are (Natalie Kimani, 2016) as follows:

- Some clothes are not designed to recycle
- It is a complex problem to disintegrate the polyester cotton blends individually, while this combination is the major player in the market
- Where will the customers deposit the clothes that need to be recycled?
- Is there any responsible nationalized government or private agency performing this process?
- National-level implementation possibilities and technology availability
- Skill requirements to process the circular fashion concept at all levels

Based on these fundamental issues, the major barriers involved in the implementation of the circular fashion can be grouped as cultural, technological, market, and barriers related to government regulations as provided in Fig. 2.10. The main point to be considered about these barriers is they are all interrelated. The interrelatedness of the four categories of barriers may create failure to the circular fashion business if not handled properly. For each company based on their business model it is recommended to examine the four categories of circular fashion barriers and their different subcategories in detail. This will help to identify the root causes of failure regarding a transition toward a circular fashion concept from the linear one. This helps to target the issues correctly and convert the failures into positive transition toward the circular business (De Jesus and Mendonça, 2018).

2.5.1 Cultural barriers

The cultural barriers are the main barrier in implementing the circular fashion concept or circular economy concept in any business. Particularly in apparel industries, a lack of consumer interest and awareness, and company culture and operation within a linear system are the main factors.

- *Consumer interest and awareness*—The consumer's interest and awareness toward the circular fashion is the major factor acting as a barrier. The consumers are not interested to pay a more amount of money for the sustainable item. The existing readymade business models rely on volume of sales. Hence, the specific sustainable product would result in higher prices. This demotivates the customers from buying (Allwood et al., 2011). A study by Gwozdz et al. (2013) indicates that the knowledge on environmental and/or social concern is high among the youths in general and this does not translate in their purchasing patterns. They have also cited few other barriers as follows:

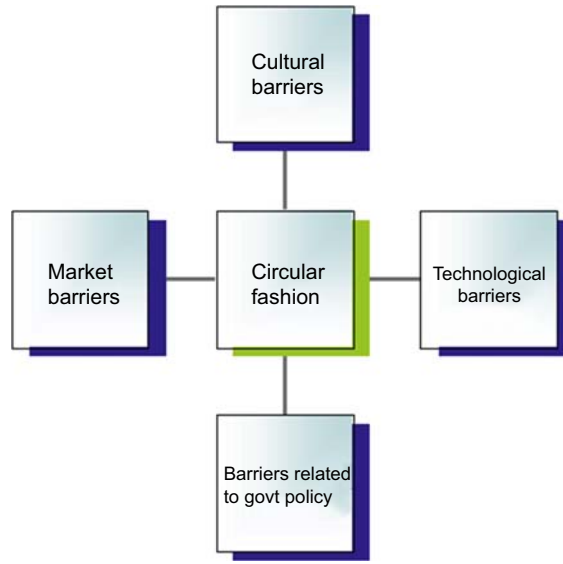

Figure 2.10 Barriers for circular fashion concept (De Jesus and Mendonça, 2018).

  - Limited availability, accessibility, and affordability of more sustainable options are perceived as major barriers to consumption of more sustainable clothing.
  - Lack of information on products is another barrier. The young consumers were able to identify only very few brands related to sustainability
- A study by the Danish Fashion Institute added some more barriers (Danish Fashion Institute and BCR, 2012) along with the abovementioned ones. The research study identified that the interest of customers toward the sustainable circular product is less because the customers believe that the sustainable garments are often considered unattractive and unfashionable. The research also mentioned that the consumers are also restricted by factors like the disincentive to repair and the lack of nontoxic alternative to dry cleaning, the washing perception on the sustainable clothing. As societies develop and people get more disposable income, they do want to buy more products which ultimately do become disposable. This habit of the consumer has led to a more transitory relationship with clothing, with perfectly good clothes disposed of before they are worn out because clothes can be more easily and conveniently replaced than repaired or modified.
- *Company culture and linear production system*—The manufacturing industries got stuck into their previous business models and they do not want to change their mode of operation. Hence, the concept of circular economy or fashion is very meagrely discussed inside the factory. They are restrictive toward implementing new operative procedures and methods. A firm can only deliver a circular product if its entire supply chain is circular. However, it is difficult for many firms to find companies that are also keen to embrace a circular business model. These factors are the other cultural factors which restrict the implementation of the circular concept in the fashion industry. For example, the manufacturer may be aware of the supplier or the primary dealer of the source but they are unlikely to know every aspect of the supply chain. The manufacturer may not be aware of the items like buttons or motifs, how they are made or sewn on. Hence, even when the manufacturer changed their procedure as circular, they cannot put their hand on their heart and say that their products are absolutely

cast-iron guaranteed that the products are squeaky clean because somebody somewhere might have subcontracted some process, about which the manufacturers have no idea.

2.5.2 Technological barriers

The technological requirement of the circular product is one the important factors to be considered (Kirchherr et al., 2017).

- The availability of the proper technology at every manufacturing stage of the circular product is necessary to produce a 100% circular product in the market.
- The existence of the technology in the different sectors of the market is still a question mark. Even when the organization is ready to innovate the new design concept and their respective manufacturing methods, the process is time consuming and very slow.
- The availability of the past data is the important factor which drives scientists and researchers to innovate new methods.
- The quality level of the recycled material needs to be improved with proper technological change with the existing process.
- In the case of apparel products, there should be a proper mechanism to collect the used clothes from the city municipal level to national level. From that process, technological challenges in sorting the recycled products into products for high-quality raw material and converting them into a high-quality product are to be established and standardized in a nationalized manner.
- There is lack of an information exchange system, rational training and skillfulness, and knowledge within businesses as well as poor distribution of data between vendors. Also, there are incomplete data and knowledge to kindle the necessity and collaboration in the supply chain.

2.5.3 Market barriers

As the circular fashion products are costly, the market for those clothing is also a niche market. The interested consumers are willing to pay extra for environmentally and socially responsible clothing. The general market barriers of circular fashion can be (de Witte et al., May 2014) as follows:

- The circular fashion market is a small segment of market and often hard to distinguish with the existing market. This particular segment involves a small group of customers, businesses, and organizations.
- The customers in this market have some specific needs and desires. Hence, to solve them, they are ready to pay extra money for apparels. This creates complexity sometimes.
- The rise in the cost of the virgin material in the market increases the manufacturing cost of the circular product at a higher level than the traditional product of the type.
- Their needs and willingness to purchase a product is again controlled by their economic capacity. Each component of the niche market has sufficient economic capacity that allows them to cover the necessary expenses for the satisfactions of their need or desire.
- The complexity of the needs require specialized operations and capable suppliers to meet customers' expectations. In some cases, the market has very few or no suppliers.

2.5.4 Barriers related to government regulations

The existing government policies and regulations are fundamentally based on the linear economic system that encourages disposal. Hence, the regulations of the governments are not contained with enough information about the circular approach. They may hinder the transition to a circular economy. According to a research by Stewart et al., legislation and policies can cause four types of barriers (Stewart et al., 2016):

1. Unclear or fuzzy messages from regulation
2. Multiple, complex, and changing regulations
3. Low pressure from regulation and a lack of control
4. Regulation limits room for innovation

The government lacks policies and norms in the area of waste collection from the different waste sources. Due to this, the wastes are mixed up and the quality spoils further and ultimately increases the recycling cost. The existing government regulations obstructs the use of recycled materials in production processes. This is due to the specific consideration on the quality of the recycled product. Manufactured products should be designed for reuse, repair, and recycle. Mostly the waste legislation focuses on quantities (weight-based collection or recycling targets) and not so much on the quality of recycled materials (Regulatory, 2016). Several researches performed by different organizations revealed that an integrated analysis of regulatory barriers and economic incentives is required in order to develop or support circular economy alternatives of prevention, reuse, or high-quality recycling. In almost all cases, regulatory barriers do not ultimately hinder or prevent more circular solutions, but they make it (sometimes unnecessarily) more costly compared to traditional linear approaches (Kirchherr et al., 2017).

2.6 Brands involved in circular business

2.6.1 MUD Jeans

MUD Jeans is a denim manufacturer who follows the circular fashion principle in their manufacturing process. In 2013 the company introduced a concept called "Lease a Jeans," an innovative approach to offer guilt-free consumption. Apart from rent, they also allow their customers to choose required numbers of jeans from their online store and return it after their wear trial. Furthermore, they collect the used jeans at their end of life and recycle that fabric into shredded fibers and again spin them into new jeans. The company has received the Sustainability Leadership Award and the Peta Vegan Awards (Something About Mud Jeans, 2018).

2.6.2 Houdini

Houdini is one of the famous European brands known for their closed loop sustainable production. The company had received the H&M & ELLE Conscious Award 2017 as

recognition of their sustainable production process. The manufacturer were mentioned that

> *We do not view sustainability as a separate area within our operations − it is an integral part of everything we do. There is no inherent contradiction between sustainability and good business; on the contrary, sustainability is a prerequisite for good business.*

The company initiated the entire sustainability model in their business. They have started the repair facility in all their retail showrooms to extend the life time of the product. They had introduced the rental model from 2013. In all Houdini outlets, renting clothes are possible. The manufacturer claims that the rental process motivates the customer to purchase products that they like and want to use for a long time only. The brand also initiated a separate section in their showrooms for secondhand clothing. By selling goods secondhand, Houdini offers more customers the possibility of using their products and also extending the life of their products. They have also set the secondhand collection box in all their outlets. To promote this process, the customer who donated the secondhand clothing will receive a 50% of the selling price from Houdini. The brand also works on recycling. They have enabled worn out clothes collection boxes in all outlets. The collected clothes will be sorted and recycled based on the fiber content (Houdini, 2018).

2.6.3 Nudie jeans

Nudie Jeans is another denim manufacturer who produces sustainable denim pants in a transparent manner. They use only 100% organic cotton for their production, which has a 46% reduced global warming potential, 70% less acidification potential, 26% reduced eutrophication potential (soil erosion), 91% reduced blue water consumption, and 62% reduced primary energy demand. The company offers free repair service to their customer and also they collect secondhand material for sale and recycling in the same store where they had brought the new item. They claim that in 2016 alone 44,021 jeans were repaired in there repair shop (Nudie Jeans, 2018).

2.6.4 H&M

From 2016, H&M launched a "Global in Store clothing collection" scheme to facilitate the customer to bring in the end of use clothes to the store and ultimately to extend the life of the product. The collected clothes were sorted by a third-party organization manually and resaled around 40%−60% of the good clothes as secondhand clothing around the world. They also directly sell 5%−10% of the clothes for reuse. The fabrics which cannot be used further are cascaded into different products. Out of the products 30%−40% of the textiles are upcycled into fiber for developing new garments. Currently, the company works hard to increase the proportion of the upcycling materials in their production. The long-term objective of the H&M is

To find a solution for reusing and recycling all textile fibre for new uses and to use yarns made out of collected textiles in their products

The program not only benefits the customers, it also benefits H&M by providing greater in-store traffic and an increase in customer loyalty (How it Works Up Close—Case Examples of Circular Products, 2014).

2.6.5 C&A

C&A is a European fashion retailer that introduced a gold-level C2C certified T-shirt into the market. The certification assesses the products and materials for safety to human and environmental health, design for future use cycles, and manufacturing methods (Cradle to Cradle Certified, 2018). This gold level of C2C is the second highest level. The product also meets the highest platinum level of requirements for material, health, renewable energy, and water stewardship, meaning that from the design stage to finished product no harmful substances are present in the product, including the dyeing process. The manufacturer also used organic cotton for the product, which is already certified as free from synthetic fertilizers and fertilizers. The accessories like labels, threads, buttons, etc. also support easier recycling, meaning that the components of the garments need not to be separated for the recycling. For the dyeing process, the manufacturer had a tie-up with DyStar to develop an eco-friendly color palate of over 100 shades from eight C2C primary color dyes which is already in the market (Cradle to Cradle, 2018). The T-shirts are designed in such a way that at the end of life they can be composted using a home decomposing unit itself within 12 weeks. The T-shirts are produced to this level by two Indian manufacturers, Blossom and Pratibha Syntex and sold in the market with an approximate price of 8.5−10.7 USD (Ellen MacArthur Foundation, 2017; Cradle to Cradle Certified, 2018).

2.6.6 Filippa K

Filippa K was founded in 1993 and is today a leading Scandinavian fashion brand. The head office is situated in Stockholm, Sweden. Filippa K's garments developed as sustainably as is possible today. The garments passes thorough sustainable life cycle assessments, where every phase of the garments' life cycle, from raw material to afterlife, is examined and adjusted with minimal ecosystem impact in mind (Filippa Circle, 2018). They claim that they have full traceability of raw material from cutting waste to garments. They also mentioned that 10 years of care is a kind of warranty system they offer. The company will help the customers to care for their products for 10 years. As a sustainability imitative, the brand also allows their customer to rent their clothing for 4 days at 20% of the full price (Lease, 2018). Furthermore, they collect old Filippa K garments that customers no longer want, which are either sold as secondhand in Filippa K's secondhand store or donated to charities. To encourage this activity, the brand returns 15% discount vouchers for the customers who donates the clothes. The brand

announced that by 2030, they will produce 100% circular fashion in the market (Circular Design Speeds, 2018).

> *We will develop circular garments where all environmental impacts and aspects during a full life cycle are taken into account and optimized based on a pre-determined life length,*
>
> *Filippa K Sustainability director Elin Larsson.*

2.6.7 Patagonia

The company is an outdoor clothing manufacturer, who manufactures surf suits and climber suits in a sustainable way. The brand manufactures sustainable clothing through its "Common Threads" initiative. The brand had mentioned their motto as (Wornwear)

> *To wrest the full life out of every piece of our clothing, the first three of the famous 4 R's become equally important—to reduce, repair, and reuse, as well as recycle. We've also learned that we can't do it alone. We can only implement the 4 R's if we do it in partnership with our customers*

The brand performs all the sustainable actions mentioned by experts. First, the brand makes clothes which are durable and long-lasting. The raw material used for the process should be either recycled or organic with minimal or no social and environmental negative influence. Patagonia also explicitly calls on its customers.

> *to buy only what she or he will wear — and want to keep long enough to wear out.*

The second initiative is repair. Patagonia offers much durable items, and however, due to the nature if some component fails, the brand replaces it for free. Thus Patagonia ensures their products' life gets extended. And the garments are also designed in such a way that all the components can be replaced if something fails unfortunately. Furthermore, the company also have a separate brand called "Worn Wear," where they collect used garments and resell it again based on the quality of the item (Patagonia), thus avoiding landfills and extending product life. The damaged and end of life products are also recycled, including clothing, baggage items, and shoes as much as possible and again made into a new Patagonia product. They have a partnership with the Japanese company Teijin to recycle synthetic materials, where the materials are again converted into feedstocks and made as new garments (Wornwear). The company's Environment Initiative Vice President explains the recycling process as,

> *Clothes go in and clothes go out.*

The chemical recycling step is preferred only after the particular product had completed its reuse cycle and while it reaches no useful life in the society.

2.6.8 Worn again

Worn Again is a UK-based textile company which produces zero waste closed loop production. The company had developed a process in which the cotton and polyester blends can be successfully separated and the cellulose can be recycled into viscose and polyester. From low-value clothing the company produces virgin equivalent, cost competitive polyester, and cellulosic raw materials to go back into the supply chain as part of a continual process. The manufacturer claims that only 0.1% of the fiber is lost in the process. There is no shortening of fiber lengths or reduction in quality, which are typical drawbacks of mechanical fiber recycling. The company collects end-of-life clothing from users and companies and waste management services and convert them into new raw materials. The cycle can repeat again and again, eliminating the need to exploit virgin resources (Wornagain).

2.7 Circular fashion—Indian context

Before the year 2000, the purchase behavior of the Indian customer was so predefined. The customers used to purchase new apparels only at occasions like festivals times and family functions. To be exact, yearly two to three new apparels were the maximum purchased quantity. Accessing Western brands and quality clothes was merely impossible unless otherwise some of the family members lived abroad. But in recent times, things have changed, after the removal of the quota system, the fashion industry in India had undergone a major shift due to the entry of Western brands and retailers. The increase in the per capita income is one the major driving forces for higher consumption utilities. The increased disposable income and easy accessibility of luxury fashion by direct foreign retailer outlets and e-commerce sites are secondary factors. The mindset toward fashion consciousness, societal image, technology development, easy accessibility of all foreign brands are other factors for the major shift of Indian customers' mindset (Sustainable, 2018).

The average economic growth rate of India in the past decade is around 7.4% annually. The researchers predicts that in about 2 decades the country will became one of the four largest economies in the word, if the similar amount of economic growth is achieved (Blériot, 2016). The CEO of the National Institution for Transforming India, stated that,

> *… the country's current per capita income is $1,652. If India continues to grow at the current rate of 7% per annum, by 2032 per capita income will be $4,000 in real terms. Moreover, if the economy grew by 10% annually, the per capita income would reach $6,800 and India would be largely free from poverty by 2032.*
>
> *CEO, National Institution for Transforming India (NitiAyog) (Arpit and Apoorva, 2017a).*

With respect to the apparel and fashion industry, circular economy concepts were implemented in very few places. The implementation of this concept in the Indian

market will take a long time when compared to the westernization concept. The major barrier in the implementation of circular fashion concept in India is the "lack of awareness" among the consumer. Due to westernization, the customers currently prefer the fast fashion trends, which offer their customers a wide range of colors, styles, and function with cheaper cost. On the contrary to the fast fashion items, the circular fashion products are costlier and less fashionable one. This makes the customer reluctant to buy the sustainable product. But the positivity about the circular concept is the Indian tradition system itself fundamentally followed the same concepts like reuse and use of extended life of the product. So this implementation will not be that difficult in the Indian context. But the complexity rises only while implementing these concepts at the places like industries, business organizations, etc. This was rightly mentioned by the chief of Tata Sustainability Group as (MacCarthy, 2016),

> *Traditionally, the Indian economy has been one where reusing, re-purposing and recycling has been second nature. In a world that is increasingly running out of natural resources, this thinking is an asset that must be leveraged by businesses, policymakers and citizens in an organized manner and expanded to include other elements to make the economy truly circular,*

In the Indian market the word "sustainability" is entered and made few changes successively, but at the same time the concept of circular fashion is not in the picture till date). However, there are many Indian origin fashion brands in the market that produce sustainable clothing but not a completely circular one as mentioned by the Ellen MacArthur Foundation. Few Indian sustainable brands and their sustainable acts are detailed as follows (Pandey, 2017),

- **péro**—The brand uses only the handloom textile with a "no synthetics policy." They utilize their manufacturing waste for some other surface ornamentation purposes like patchwork, etc. The brand motivates their customers to recycle their existing garments and fabric through their upcycling project (Pero).
- **Green the map**—This brand practically transforms old tires, tetra packs, waste cloths, waste leather, and other apparel wastes into new materials. They use poor background tailors for this purpose with good work environment (Greenthemap, 2018).
- **Upasana**—This is one of the leading sustainable fashion brands in India. The brand's motto is to produce 100% organic garments with a mission to "design to change" without harming the environment. The main advantage of this brand is the general use of organic cotton, handloom manufacturing, herbal dyeing process, and traditional handmade printing methods like batik, ikat, etc. They also upcycle their manufacturing waste into cost-effective products and components of their designs (Upasana).
- **Do U Speak Green**—It is India's first fashion brand-cum-web store that manufactures garments form organic bamboo and cotton fabric in Fair trade−certified factories. Furthermore, the brand dedicates its 10% of sales value to environmental conservation processes (Douspeakgreen, 2018).
- **Bhusattva**— It was one of the earliest defenders of sustainability in the Indian textile industry. They believe in innovating their processes using technology like infusing bamboo, banana, soya bean fibers and blending it with khadi, silk, and cotton to make it compatible with mainstream fashion (Bhusattva, 2018).

- **No Nasties**—The brand is India's first fair trade–licensed label which has a strict policy of 100% organic textile and ethical policies toward craftsmanship. The brand proposed this strategy as an initiative to stop farmer's suicides in India. The brand's current initiatives in India is to address this issue with "organic" and "fair trade" farming practices (Nonasties).
- **Doodlage**—It is an upcycling brand that believes in the art of recycling waste fabrics into beautiful, eco-friendly patchwork clothing and home furnishings (Doodlage, 2018).

Other than these, many Indian designers have started their eco-friendly product labels to address sustainability issues in the fashion sector. Brands like Bodice, Bhoomki, Hidesign, Brass Tacks and designers like Swati Kalsi, Anupama Dayal, Paromita Banerjee, Samant Chauan, and Anita Dongre are currently working on sustainable concepts in their brand labels (Sustainable Fashion, 2016). However, the approach toward total circular fashion and circular economy is still not fully covered in the Indian fashion industry. Recently, a new report from the Ellen MacArthur Foundation released on the topic, "*Circular Economy in India: rethinking growth for long-term prosperity*" focused on the three areas which are key to the Indian economy and society: namely, cities and construction, food and agriculture, and mobility and vehicle manufacturing (Joe, 2016). The research reported that the implementation of the circular economy principle in the selected area could bring an annual benefit equivalent to 624 billion USD in 2050 in comparison with the current developing path and which is equivalent to 30% of the India's current GDP. The report also revealed that the implementation could also reduce by 44% of the greenhouse gas emissions in 2050 (Ellen MacArthur Foundation, 2016). The most recent boost to this sustainable fever was established through one of India's popular fashion shows, Lakme Fashion Week (LFW) Winter Festive 2017 in Mumbai. The first day of the show is celebrated as "Sustainable Fashion Day" by the organizers. On this first day, multiple events and shows were conducted to enhance the awareness toward sustainable fashion. Particularly, to make awareness toward upcycling processes, an even named "Restart Fashion" was conducted, where, three postconsumer waste fabrics were provided to designers to create fashion from discarded and upcycled materials. The fashion week brought the idea about environmentally responsible fashion through leading fashion designers (Vasudev, 2017).

Though India had a traditional system similar to circular fashion, India is currently following the Western path of linear economic production and consumption. The important driving factor from this situation is conscious consumerism, which drives the Indian economy toward the circular economic principle in all sectors of industry, including textile and apparel. In the perspective of government policies, there is a need for a revamped in existing systems like ecological taxation and financial incentives for reforms toward a circular economy. The revamp should be addressed in such a way that there should not be any declination in the country's growth. "Make in India" is one of the recent initiatives by the Indian government to promote sustainability and textile and apparel manufacturing sectors (Hammond, 2018). The major role player in the Make in India movement related to the apparel and textile industry is Apparel Export Promotion Council (AEPC). The AEPC launched the Indian apparel industry sustainability program by aiming toward the carbon footprint reduction in the

manufacturing process. The Tirupur knitwear cluster is a good example of how regional investment can strengthen the economic and social developments, and the role of Tirupur Export Association is major in innovating sustainable manufacturing process in that region. Different Indian apparel manufacturers are using Global organic Textile standard' (GOT's) certification as new business opportunities to attract new customers (Hammond, 2018). This kind of investments made by the governments develops long-term stability in the business. However, to sustain in the market India needs to develop innovation in the market. The regulatory framework of the Indian industry should be designed in such a way that specifies explicit ends but leaves the means open for innovation. These kinds of supportive government policies are the major driving factors of Indian industries toward the circular fashion. As a next step toward sustainability, in a recent talk at the St Petersburg International Economic Forum, 2017, the Prime Minister of India, Mr. Narendra Modi, mentioned the supportiveness of the Indian government toward sustainable manufacturing in his speech as (Arpit and Apoorva, 2017b),

> *Paris or no Paris, it is our conviction that we have no right to snatch from our future generations, their right to have a clean and beautiful earth. It is part of our thinking and for that reason we do not believe in exploitation of the nature. We people do not have the right to take more than necessary from nature.*

2.8 Summary

The chapter elucidated the impact of the linear economic model in the society in detail and also outlined the importance of the circular economic principle in the modern era. The concept of circular fashion has been described with its important principles. The requirements of the fashion industry to adapt the circular economy were stressed in terms of the environmental impact of fast fashion and readymade society. The possibilities to implement the circular fashion concepts from the design to user stage was summarized along with the potential barriers a company or an individual can face during the adaption of circular economy. The possible alternative business models that can be adapted in the fashion industry to extend the life of fashion products were also mentioned in the report from the previous research work. The chapter also presented as examples a few successful brands which already perform their business operations with the circular fashion concept in international and Indian contexts. In consolidation, the chapter enlightens the fundamental concepts of circular economy and their implication along with their importance in the fashion industry.

References

About Earth Overshoot Day, 2018. https://www.overshootday.org/about-earth-overshoot-day/.
Accenture, 2014. Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth.

Allwood, J.M., et al., 2011. Material efficiency: a white paper resources. Conservation and Recycling 55 (3), 362−381.
Anonyms, 2013. Clothing Swap. http://www.hawaiilibrary.net/article/whebn0011418039/clothing%20swap.
Arpit, B., Apoorva, A., 2017a. Realising Circular Economy Opportunities in India. http://circulatenews.org/2017/01/realising-circular-economy-opportunities-india/.
Arpit, B., Apoorva, A., 2017b. Building Blocks of a Circular Economy in India: The Role of Public Policy. https://www.huffingtonpost.com/entry/building-blocks-of-a-circular-economy-in-india-the_us_5970b7a1e4b0f68541cd62d3.
Bhusattva, 2018. http://www.bhusattva.com/.
Blériot, J., 2016. Is India Ready to Embrace the Circular Economy? https://www.weforum.org/agenda/2016/12/is-indias-future-circular/.
Bocken, N.M.P., de Pauw, I., Bakker, C., van der Grinten, B., 2016. Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering 33 (5), 308−320.
Braw, E., 2014. Five Countries Moving Ahead of the Pack on Circular Economy Legislation. https://www.theguardian.com/sustainable-business/2014/oct/29/countries-eu-circular-economy-legislation-denmark-sweden-scotland.
Circular Design Speeds, 2018. http://mistrafuturefashion.com/circular-design-speeds/.
Circular Economy Promotion Law of the People's Republic of China, 2008. http://www.fdi.gov.cn/1800000121_39_597_0_7.html.
Circular Fibres Initiative Analysis Based on Euromonitor International Apparel & Footwear 2016 Edition (Volume Sales Trends 2005−2015), 2016.
Circular Fibres Initiative Materials Flow Analysis and Euromonitor International Apparel & Footwear, 2016. Edition (volume sales trends 2005−2015).
Cision, P.R., 2016. Newswire, Rent the Runway Raises $60 Million in Series E Funding Led by Fidelity Investments.
"Closing the Loop" in the Fashion Industry, 2013. http://www.greenstrategy.se/closed-loops-fashion-textile-industry-definition-and-challenges-2/.
Cradle to Cradle, 2018. http://www.dystar.com/cradle-cradle.
Cradle to Cradle Certified, 2018. http://www.c-and-a.com/uk/en/corporate/company/materials.
Danish Fashion Institute & BCR, 2012. The NICE Consumer: Toward a Framework for Sustainable Fashion Consumption in the EU. Retrieved from. http://www.bsr.org/reports/BSR_NICE_Consumer_Discussion_Paper.pdf.
De Jesus, A., Mendonça, S., 2018. Lost in transition? Drivers and barriers in the eco-innovation road to the circular economy. Ecological Economics 145, 75−89.
de Witte, D., Pino, A., Hernandez, A., Angel Orduño, M., Bayramova, C., May 2014. Conditions for sustainable fashion initiatives - a case local study for Catalonia. In: 7th International Seminar on Sustainable Technology Development, vol. 27. Universitat Politècnica de Catalunya.
DEFRA, 2012. Resource Security Action Plan: Making the Most of Valuable Materials.
Doodlage, 2018. https://www.doodlage.in/#.
Douspeakgreen, 2018. http://douspeakgreen.in/.
Ellen Macarthur Foundation, 2012. Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition. Ellen MacArthur Foundation, UK.
Ellen MacArthur Foundation, 2016. Circular Economy in India: Rethinking Growth for Long-Term Prosperity. http://www.ellenmacarthurfoundation.org/publications/.
Ellen MacArthur Foundation, 2017. A New Textiles Economy: Redesigning Fashion's Future. http://www.ellenmacarthurfoundation.org/publications.

Eurostat Waste statistics (2011), https://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Waste_statistics.
Eva Guldmann Best Practice Examples of Circular Business Models, 2016. The Danish Environmental Protection Agency. Denmark. https://www2.mst.dk/Udgiv/publications/2016/06/978-87-93435-86-5.pdf.
EY, 2015. Are You Ready for the Circular Economy? The Necessity of an Integrated Approach. Available at: http://www.ey.com/Publication/vwLUAssets/EY-brochurecas-are-you-ready-for-the-circular-economy/$FILE/EY-brochure-cas-are-you-readyfor- the-circular-economy.pdf.
Fletcher, K., 2014. Sustainable Fashion and Textiles: Design Journeys, p. 42.
Flippa Circle, 2018. http://filippakcircle.com/.
Frosch, R.A., Gallopoulos, N.E., 1989. Strategies for manufacturing. Scientific American 261 (3), 144−152.
Ganit, S., 2016. Fast Fashion Has Changed the Industry and the Economy. https://fee.org/articles/fast-fashion-has-changed-the-industry-and-the-economy/.
Ganit, S., 2016. Fast Fashion Has Changed the Industry and the Economy. https://fee.org/articles/fast-fashion-has-changed-the-industry-and-the-economy/.
Gartner, 2015. Market Share Analysis: Consulting Services, Worldwide. Available at: https://www.gartner.com/doc/3317117/market-share-analysis-consultingservices, 2016.
Geissdoerfer, M., et al., 2017. The circular economy − a new sustainability paradigm. Journal of Cleaner Production 143, 757−768.
Geyer, R., Jackson, T., 2004. Supply loops and their constraints: the industrial ecology of recycling and reuse. California Management Review 46 (2), 55−73.
Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production 114, 11−32.
Gina-Marie, C., 2016. The High Environmental Cost of Fast Fashion. https://www.triplepundit.com/2016/12/high-environmental-cost-fast-fashion/.
Greenthemap, 2018. https://www.greenthemap.com/.
Gwozdz, W., Netter, S., Bjartmarz, T., Reisch, L.A., 2013. Report on Survey Results on Fashion Consumption and Sustainability Among Young Swedes. Retrieved from: http://www.mistra.org/download/18.235dce8d1429b736de3406/1386697330067/Report+Mistra+Future+Fashion+Consumer+behaviour+2013.pdf.
Hammond, L., 2018. Gaps Remain in India's Move Towards Sustainability. https://www.just-style.com/comment/gaps-remain-in-indias-move-towards-sustainability_id132611.aspx.
Hannon, E., Kuhlmann, M., Thaidigsmann, B., 2016. Developing Products for a Circular Economy. Available at: http://www.mckinsey.com/business-functions.
Hans Stegeman, 2015. The Potential of the Circular Economy. https://economics.rabobank.com/publications/2015/july/the-potential-of-the-circular-economy/.
Hestin, M., Chanoine, A., Menten, F., 2016. Circular Economy Potential for Climate Change Mitigation. Available at: https://www2.deloitte.com/content/dam/Deloitte/fi/Documents/risk/Deloitte-Circular economy and Global Warming.pdf.
Houdini, 2018. https://www.houdinisportswear.com/en/sustainability.
How it Works Up Close—Case Examples of Circular Products, 2014. http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/how-it-works-up-close-case-examples-of-circular-products/.
Ingebrigtsen, S., Jakobsen, O., 2006. Circulation economics-a turn towards sustainability. International Journal of Social Economics 33 (8), 580−59.

International Energy Agency, 2016. Energy, Climate Change & Environment: 2016 Insights, p. 13.

Joe, I., 2016. Why a Circular Economy Would be Good News for India. https://www.huffingtonpost.com/ellen-macarthur-foundation/why-a-circular-economy-wo_b_13740130.html.

Lease, Filippa K., 2018. A Way to Sustainable Consumption. https://www.filippa-k.com/se/filippak-world/lease/.

Kant, R., 2012. Textile dyeing industry: an environmental hazard. Natural Science 4 (1), 23.

Kerli Kant, H., 2016. Weaving a Path from Waste to Value: Exploring Fashion Industry Business Models and the Circular Economy. Doctoral School of Organisation and Management Studies, Copenhagen Business School.

Kipping, M., Clark, T., 2012. The Oxford Handbook of Management Consulting. Oxford University Press, Oxford, United Kingdom.

Kirchherr, J., Hekkert, M., Bour, R., 2017. Breaking the Barriers to the Circular Economy. https://www.uu.nl/sites/default/files/breaking_the_barriers_to_the_circular_economy_white_paper_web.pdf.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. Resources, Conservation and Recycling 127, 221−232.

Lacy, P., et al., 2015. Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth. Available at: https://www.accenture.com/t20150523T053139__w__/us-en/_acnmedia/Accenture/Conversion- Assets/DotCom/Documents/Global/PDF/Strategy_6/Accenture-Circular-Advantage-Innovative-Business-Models-Technologies-Value-Growth.pdf.

Lee, B., Preston, F., Kooroshy, J., Bailey, R., Lahn, G., 2012. N. Asia, & S. Asia. Resources Futures 249.

Leonard, G.H., 2016. Oceans, Microfibers and the Outdoor Industry: A Leadership Opportunity. Presentation to Outdoor Industry Association.

Limits of Linear Consumption, 2014. http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/the-limits-of-linear-consumption/?doing_wp_cron=1513832620.8095760345458984375000#view/fn-2.

MacCarthy, L., 2016. Circular Economy Framework Could Give India a Competitive Advantage. http://www.sustainablebrands.com/news_and_views/next_economy/libby_maccarthy/circular_economy_framework_could_give_india_competitive_.

McDonough, W., 2002. Cradle to Cradle: Remaking the Way We Make Things. North Point Press, New York.

McDonough, W., Braungart, M., 2013. The Upcycle − Beyond Sustainability − Designing for Abundance. Melcher Media, New York.

McKinsey Commodity Price Index, 2013. https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution-tracking-global-commodity-markets.

Meyer, B., 2012. Macroeconomic Modelling of Sustainable Development and the Links between the Economy and the Environment. Research Report I, GWS.

Ministry of Textiles, 2017. Department of Industrial Policy and Promotion, Press Information Bureau, Union Budget 2017-18. https://www.ibef.org/industry/textiles.aspx.

Mont, O.K., 2002. Clarifying the concept of product−service system. Journal of Cleaner Production 10 (3), 237−245.

Kimani, N., 2016. Circular Fashion: Is it Time for Closed-loop State of Mind? http://tdsblog.com/circular-fashion-time-closed-loop-state-mind/.

Niinimäki, K., Hassi, L., 2011. Emerging design strategies in sustainable production and consumption of textiles and clothing. Journal of Cleaner Production 19, 1879.
Nonasties. www.nonasties.in.
Nudie Jeans, 2018. https://www.nudiejeans.com/page/this-is-nudie-jeans#repair.
Origin of the Concept Circular Fashion, 2015. https://circularfashion.com/circular-fashion-definition/.
O'Connor, M.C., 2017. Inside the lonely fight against the biggest environmental problem you've never heard of, the Guardian (27 October 2014). International Union for Conservation of Nature, Primary Microplastics in the Oceans: A Global Evaluation of Sources 20–21.
Pandey, A., 2017. Indian Sustainable Fashion Brands You Need To Know About. http://www.currentmoodmag.com/2017/06/22/indian-sustainable-fashion-brands-you-need-to-know-about/.
Patagonia. http://www.patagonia.com/recycled-down.html.
Pedersen, E.R.G., Netter, S., 2008. Collaborative consumption: business model opportunities and barriers for fashion libraries. Journal of Fashion Marketing and Management: An International Journal 19 (3), 258–273.
Pero. http://pero.co.in/.
Product-Life Factor (Mitchell Prize Winning Paper), 1982. http://product-life.org/en/major-publications/the-product-life-factor.
Regulatory, 2016. Regulatory Barriers for the Circular Economy: Lessons from Ten Case Studies. http://ec.europa.eu/growth/content/regulatory-barriers-circular-economy-lessons-ten-case-studies-1_en.
Rent Shell Layers and Minimize Your Environmental Impact, 2018. https://www.houdinisportswear.com/en/sustainability/houdini-rental.
Sarah McInerney Swap till Your Fashion Footprint Drops, 2009. http://www.smh.com.au/lifestyle/shopping/swap-till-your-fashion-footprint-drops-20090709-ddx7.html.
Lu, S., 2017. Market Size of the Global Textile and Apparel Industry: 2015 to 2020. https://shenglufashion.wordpress.com/2017/06/06/market-size-of-the-global-textile-and-apparel-industry-2015-to-2020/.
Shwe Gaung, J., 2017. YCloset Raises Series B $20m from Pan-Lin Asset. IDG, Deal Street Asia.
Sixteen Principles for a Circular Fashion Industry, 2015. https://circularfashion.com/key-principles/.
Something About Mud Jeans, 2018. http://www.mudjeans.eu/about-mud-jeans/.
Stahel, W., 1981. The product-life factor. In: Grinton Orr, S. (Ed.), An Inquiry into the Nature of Sustainable Societies: The Role of the Private Sector. HARC, Houston, TX, pp. 72–96.
Stahel, W.R., 1994. The utilization focused service economy: resource efficiency. In: Allenby, B.R., Richards, D.J. (Eds.), The Greening of Industrial Ecosystems. National Academy Press, Washington, DC, pp. 178–190.
Stahel, W.R., Reday-Mulvey, G., 1976. Jobs for Tomorrow: The Potential for Substituting Manpower for Energy. DG Manpower. European Commission, Brussels.
Stewart, R., Bey, N., Boks, C., 2016. Exploration of the barriers to implementing different types of sustainability approaches. Procedia CIRP 48, 22–27.
Sustainable Adrienna, Is Fashion Sustainable in India?, 2018. http://www.circulareconomyasia.org/is-fashion-sustainable-in-india/.
Sustainable Fashion, 2016. https://www.trustedclothes.com/blog/2016/06/21/sustainable-fashion-designers-in-india/.
The Life Cycle of a Jean- Understanding the Environmental Impact of a Pair of Levi's® 501® Jeans, 2016. Levi Strauss & Co, US Fashion Industry Association. http://www.

usfashionindustry.com/pdf_files/02042016-USFIA-BCI-Levi-SustainabilityPresentation.pdf.
The Problems of Our Ready-Made Society, 2017. https://circularfashion.com/the-problems-of-our-ready-made-society/.
Towards Circular Economy, Report 1, 2013. Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/.
Towards Circular Economy, Report 2, 2013. Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/.
Towards Circular Economy, Report 3, 2014. Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/.
UNEP, 2011. Decoupling Natural Resource Use and Environmental Impacts from Economic Growth. International Resource Panel.
Upasana. http://www.upasana.in/.
Vasan, P., 2015. Rent the Runway's Designer Closet Tops $800 Million. CNBC.
Vasudev, S., 2017. Sustainability is the New Trend in Indian Fashion. But What Does It Really Stand For? https://www.hindustantimes.com/opinion/sustainability-is-the-new-trend-in-india-s-fashion-industry-but-can-it-last/story-KZvx9SR4e4i7XHZiErgFnK.html.
Watson, D., et al., 2016. Exports of Nordic Used Textiles: Fate, Benefits and Impacts, p. 67.
World Footprint, 2018. https://www.footprintnetwork.org/our-work/ecological-footprint/.
Wornagain. http://wornagain.info/.
Wornwear. https://wornwear.patagonia.com/how-it-works.
WRAP, 2016. SCAP Textiles Tracker Survey.
Zhijun, F., Nailing, Y., 2007. Putting a circular economy into practice in China. Sustainability Science 2 (1), 95−101.

Tools for circular economy: review and some potential applications for the Philippine textile industry

3

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3.1 Introduction

Sustainability continues to be enigmatic, evasive, and a huge challenge to industrial operations, especially among the developing nations such as the Philippines. Thus, the search for ways and means to decipher and materialize sustainable operations in the developing zone is kept on. The footprints of industrial operations constitute the huge part to look into for this point, while current discourses on circular economy (CE) have to tackle insights into the management of these footprints for exactly the same purpose. Irrespective of geographical concerns, sustainability is articulated in the United Nations Sustainable Development Goals (UNSDGs) that determine what must be achieved in the soonest possible time to comply with the requirements of planetary boundaries or the "safe operating space for humanity" (Griggs et al., 2013; Steffen et al., 2015; Lu et al., 2015). The CE concept has a complementary role in sustainability to guard the planetary boundaries with its paradigm in which footprints (environmental, economic, and social) are ably managed with appropriate (environment-friendly, economically sound, and socially acceptable) technologies and government and business/industry relationships and policies.

CE has stood out because of the fact that it stresses the importance of searching science solutions toward closing the loop, that instead of ending production and consumption with waste disposal, waste is minimized at source and raked back into the economy for reuse. Currently, to close the loop seems farfetched but hints to be achievable into the future with systemic innovations. Innovations are the specific requirements under which technologies and interrelationships directed toward instituting CE will work. This fact has propelled advanced economies to take the initiatives of seeing CE to take ground in carrying out sustainable practices. China still leads the aggressive efforts toward getting CE on the ground, particularly with the passage of its Circular Economy Law in 2008 (CIRAIG, 2015). The country has ongoing collaborations with European institutions to craft a sound CE roadmap (SINCERE, 2015).

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00003-0

Other advanced nations such as Japan, Canada, Germany, the United States, the Netherlands, and other European nations have been on CE (only with a different label) much earlier and yet have continued the efforts of making CE a reality (Korhonen et al., 2017).

Along with other nations joining them, the aforementioned nations have moved on the works on CE establishment/development with much inclusivity in scientific approaches. A reason for doing so is to get a more comprehensive foresight on the requisites, outcomes, costs, and benefits of making current economies gradually circular. This work particularly contributes to the efforts of configuring CE for an industry and/or a nation. The principles with which CE is thought about and the tools and the various cocktails resulting from combining tools and methods are tackled in the following sections. The triple bottom-line framework of sustainability with economic, environmental, and social pillars, despite unclear essential distinction among these pillars (Kuhlman and Farrington, 2010), are still adopted as the main structure of presenting the tools and/or combinations of which that have been applied for the study on CE. Some of these tools are linked to the textile industry particularly in the Philippines to give insights on evaluating the said industry's conformance to sustainability in the country. Like other industries across the world, the textile industry is in need of insights in which its economic, environmental, and social footprints are important to be managed well to consequently align to sustainability.

3.2 Sustainability and circular economy

Sustainability and CE are two concepts intertwined tightly—that is, it is difficult to think of a state wherein sustainability can be achieved without CE and vice versa. This goes to say that the concepts complement each other very well that it almost takes a chicken or egg scenario. The UNSDGs have operationalized sustainability that is largely directed to look forward for and look after the next generation. Discussions on sustainability are galvanized around the Brundtland report's oft-cited definition that is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987 as cited by Kuhlman and Farrington, 2010). Kuhlman and Farrington (2010) had asserted to stick to this definition as it concisely subsumes the right meaning. With that definition, the tension between the desire to live a good life and the limit to the stock of natural resources available to attain such a life is properly acknowledged (Kuhlman and Farrington, 2010). This tension leads to the concepts of weak and strong sustainability. Both need to be properly understood in the sense that they have implications to the degree of conservation, restriction, and adjustment in the use of the current stock of natural resources for the well-being of the present generation and for the future generation as well.

Moreover, the limit to the availability of natural resource stock for the future underlies a great challenge. Most works on sustainability if not all is concerned on either pushing out the limits or immensely decelerating the approach toward the said limits. The planetary boundaries specify conveniently these limits because they provide the

necessary description on the current status of the world safety for mankind. These boundaries provide specifically the present generation the guide to check and correct fervently the present ways of using up natural resources in view of the needs of the future. The aforementioned weak and strong sustainability give out the conditions for when to cross and not cross the thresholds for natural resources (Kuhlman and Farrington, 2010). In this context, a strategy and paradigm that respects the thresholds and endeavors for no infringement of them is extremely important to be established. CE is a timely concept that brings forth promising systemic solutions, which at this time is still a tall order (Balanay and Halog, 2016) and thus extremely difficult to institute. CE is a large-scale industrial ecology that aims to minimize environmental footprints through adherence to maximum efficiency, use of renewable resources, extension of product service lives, and designing out waste (Ellen MacArthur Foundation, 2013). The Ellen MacArthur Foundation champions the advocacy of it internationally and has devoted a website for entirely understanding, fathoming, instituting, and promoting CE among industries and governments worldwide.

Fig. 3.1 shows the famous illustration of CE as conceptualized by the Ellen MacArthur Foundation. The strategies toward circularity are shown in the figure, in which nothing should get out of the industrial system as much as possible to signify its footprints from industrial operations. According to CIRAIG (2015), there are principles that allow the development of circularity and these are based on the

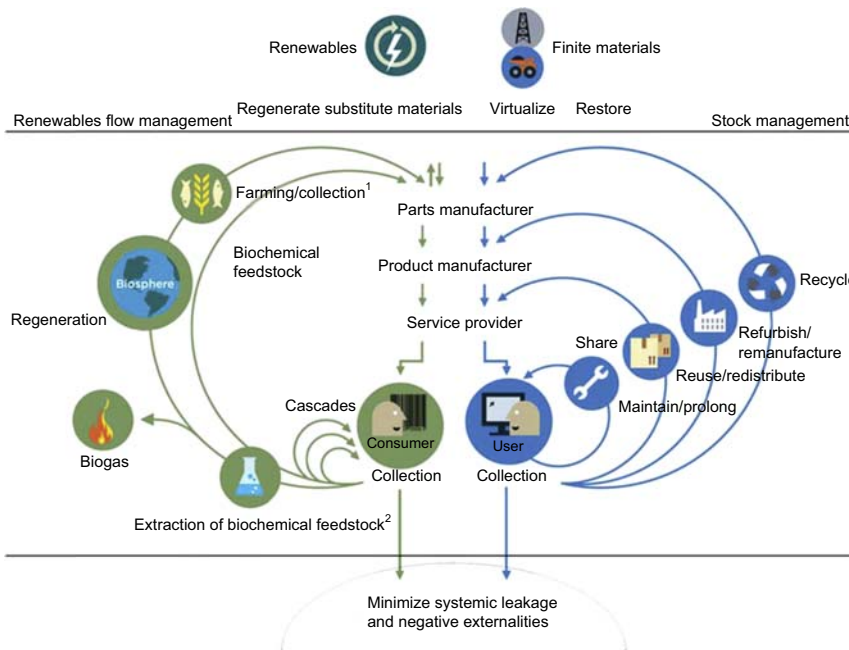


Figure 3.1 The circular economy (Ellen MacArthur Foundation, 2013 as cited by Balanay and Halog, 2016).

contentions of adopting the systems thinking (effects and impacts rippled throughout the system and everybody should get concerned), waste as essential as food (and should not just be thrown away), strength in diversity (multipartite, multisectoral, and multilateral in participation, coordination, and cooperation), designing waste out (finding wealth in waste) and renewable energy (to avoid depletion of nonrenewable energy sources such as fossil fuel) (Box 3.1). Use of renewable energy with maximum efficiency in the use of raw materials for product manufacture lays down the groundwork for CE. The consequent view of waste as an important resource for utilization and the general agreement and support for the reutilization of waste are the next to play to develop circularity. This makes CE a system with a broad base of support because every entity in the system has to facilitate the adoption of circular initiatives and strategies. Research and academic institutions have to provide fast adequate science and/or technological backstop to make maximum efficiency in operations, designing waste out, and seamless integration of circular initiatives and strategies possible.

CIRAIG (2015) identified many earlier initiatives to have close links to CE and this just pervades the willingness of many individuals and groups across the world to respect the thresholds, live within the limits, and secure a "safe operating space for humanity." Regarded as building blocks of CE are the concepts on sustainable development, ecological transition, green economy, functional economy, life cycle thinking, cradle-to-cradle thinking, shared value, industrial ecology, extended producer responsibility, and ecodesign (CIRAIG, 2015). A brief description of each concept is shown in Box 3.2. Thus, sustainability as interchangeably used with sustainable development is already interwoven into CE initiatives, which makes both concepts inextricable. Thus, CE is a platform for which sustainability can be attained essentially. However, as aforementioned, achieving circularity in industrial operations is not as easy as it may have been discussed here. Korhonen et al. (2017) have tackled at length the limits faced with trying to develop a CE, of which rebound effects are a part of many based on various dimensions (Box 3.3). Thus, the work ahead for CE is still immense as it is seemingly an insurmountable challenge and attaining sustainability is exactly in the same way with respect to securing that safe space for humanity.

Box 3.1 Five pillars of circular economy

- Systems thinking
- Waste is food
- Diversity is strength
- Design out waste
- Renewable energy

Based on the Ellen MacArthur Foundation as cited by CIRAIG., 2015. Circular Economy: A Critical Literature Review of Concepts. Available at: www.ciraig.org/pdf/CIRAIG_Circular_Economy_Literature_Review_Oct2015.pdf.

Box 3.2 The building blocks of circular economy

1. Sustainable development—a polysemic concept that deals with meeting the needs of the present generation without compromising the ability to meet the needs of the future generations.
2. Ecological transition—a multidimensional concept that takes on some equivalents in sustainability transition, transition toward a low carbon economy and socioecological transition, or a transformation process toward a more sustainable societal model.
3. Green economy—based on the UN's definition, an economy that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities.
4. Functional economy—relates to the coproduction of integrated solutions for products and services that meet households and industry expectations between providers and beneficiaries, consolidating new environmental and social requirements (Gaglio et al., 2011 as cited by CIRAIG, 2015).
5. Life cycle thinking—a holistic perspective to reach total environmental optimization throughout the product's life cycle.
6. Cradle-to-cradle thinking—a nature-inspired, biomimetic design philosophy (Braungart and McDonough, 2002 as cited by CIRAIG, 2015) which is aimed to create products with a positive environmental footprint (Bor et al., 2011 as cited by CIRAIG, 2015).
7. Shared value—a management approach focused on creating measurable business value by identifying and addressing social problems that intersect with their business (Shared Value, 2015).
8. Industrial ecology—an industrial ecosystem in which the use of energies and materials are optimized, wastes and pollution are minimized, and there is an economically viable role for every product of a manufacturing process (ISIE, 2015).
9. Extended producer responsibility—an environmental policy approach in which a producer's responsibility for a product is extended to the postconsumer stage of a product's life cycle.
10. Ecodesign—focuses on the integration of environmental considerations into product development (Karlsson and Luttropp, 2006 as cited Bovea and Pérez-Belis, 2012).

CIRAIG., 2015. Circular Economy: A Critical Literature Review of Concepts. Available at: www.ciraig.org/pdf/CIRAIG_Circular_Economy_Literature_Review_Oct2015.pdf.

3.3 Tools for circular economy-economic dimension

The use of tools for analysis in CE studies is largely governed by the building blocks mentioned in Box 3.3. Specifically, adherence to systems thinking and life cycle thinking is markedly distinguishable in the choice of analytical tools associated with CE for sustainability issues. Although Kuhlman and Farrington (2010) contend to stick to the Brundtland report in defining sustainability and not to mind translating it into certain dimensions (e.g., economic, environmental, and social) as in the triple bottom

Box 3.3 Limits and challenges for the circular economy concept

1. Thermodynamic limits
   a. Cyclical systems consume resources and create waste and emissions
2. System boundary limits
   a. Spatial: problems are shifted along the product life cycle
   b. Temporal: short-term nonrenewables use can build long-term renewable infrastructure
3. Limits posed by physical scale of the economy
   a. Rebound effect, Jevons paradox, and boomerang effect
4. Limits posed by path dependency and lock-in
   a. First technologies retain their market position despite of inefficiency
5. Limits of governance and management
   a. Intraorganizational and intrasectoral management of interorganizational and intersectoral physical flows of materials and energy
6. Limits of social and cultural definitions
   a. The concept of waste has a strong influence on its handling management and utilization.
   b. The concept is culturally and socially constructed.
   c. The concept of waste is always constructed in a certain cultural, social, and temporal context and this context is dynamic and changing.

Kornohen et al. (2018).

line, the importance of sorting sustainability into the said dimensions is actually on the associated conditions with which industrial practices can be likely adjudged sustainable (e.g., costliness, resource efficiency, and so on). Foremost, economic sustainability reckons the performance and total costs of a system, say over a certain life cycle, with the benefits and costs based on business and customer's perspectives (Wübbenhorst, 1984 is cited by Finkbeiner et al., 2010 and Kaufman, 1970 as cited by Finkbeiner et al., 2010; Eyerer, 1996 is cited by Finkbeiner et al., (2010) and Finkbeiner et al., 1999 as cited by Finkbeiner et al., 2010; Guinée et al., 2004).

Particularly, the positive economic net benefits provide the motivation for continuing a practice that works because such practice is not costly, even in green accounting terms where due to efficiency, it does not produce voluminous waste and emissions. Life cycle costing is perhaps the most popular method for evaluating economic sustainability, which as the term implies is structured on the life cycle of a product or process. As such, accounting of costs and benefits is usually from raw material extraction (cradle) to the end of life or disposal (grave) of the product. The scope of cost−benefit evaluation based on life cycle can be defined through a goal and scope definition process considering the functions of the system, the functional unit, the system to be studied, the system boundaries, the allocation procedures, the type of impact and the methodology of impact evaluation/assessment with associated interpretation, the data requirement, the assumptions, the limitations, the initial data quality

requirements, the type of critical review, and the type and format of the evaluation/assessment report (Jensen et al., 1997). Using the life cycle of a chair, Heijungs et al. (2012) clearly demonstrated the scoping process.

The terms cradle to cradle, cradle to gate, and cradle to grave are used to indicate the scope of evaluation with life cycle costing. Generally, cradle to cradle begins with raw material extraction or procurement and ends with product storage for some purposes (e.g., market speculation). This is especially true for precious metals wherein after their production they will be kept for speculative business transactions. Cradle to gate is common among intermediate products and is associated with the scope from raw material extraction or procurement until the point at which the product becomes a raw material for another production process. Cradle to grave is the term used to indicate the scope starting from the raw material extraction or procurement to the disposal of the product in landfills. Life cycle costing is the oldest method of life cycle evaluation, which precedes the life cycle assessment (LCA) commonly used for environmental impacts (Steen, 2005). Hong et al. (2011) used this method in the study of aluminum-silicon alloys in China wherein the environmental impacts are noted with associated costs pertaining to carbon emission, energy, and raw material supply particularly. Various products and processes have already been used with life cycle costing since its conceptualization in the 1970s (Steen, 2005) to determine sustainability implications. Examples of recent applications of life cycle costing in various aspects are shown in Table 3.1.

The current application of life cycle costing otherwise known as economic LCA is yet limited and largely unexplored in the textile industry. The work of Maia et al. (2012) had established the merit of using it in sustainability analysis particularly of the textile industry; however, the method is more insightful when used with environmental and/or social LCA than when used as a stand-alone procedure (Hannouf and Assefa, 2016). Life cycle costing is rather sensible at the micro level (firm or industry) than at the macro (societal or global) level (Hannouf and Assefa, 2016). In the argument of Hannouf and Assefa (2016), LCC is on point as to its relevance to sustainability analysis, the inclusion of which will guide properly the transition toward making the production of environment-friendly and socially acceptable products viable.

3.4 Other economic tools

Benefit–cost analysis (BCA) is perhaps the most basic tool for economic analysis. Relative to economic sustainability, the Ellen MacArthur Foundation has identified it as a relevant analytical tool, which even before the discourse on CE has been widely used already for concerns on determining the viability and sustainability of various program and business engagements. The other tools that can be related to economic sustainability and CE are those developed by the Project SINCERE in China. Project SINCERE is a joint initiative of China and Europe whose aim is to formulate new economic models to explain the resource use patterns in both areas (SINCERE, 2015). Some outputs relevant to the economic dimension of CE are found in the works of Lu et al. (2015) who have used Multi-scale Integrated Analysis of Societal and

Table 3.1 Recent studies analyzed with life cycle costing

Author/s	Year published	Topics and findings
Hu, M., Miranda-Xicotentat, B., Ita-Nagy, D., Prado, V., Guinée, J., van Roekel, E., Huismans, R., Rens, F., Lotfi, S., Di Maio, F.	2017	• Demolition Waste Management • Between best practice and business as usual, the former was found to be better with a life cycle cost reduction equal to 23%. The cost reduction is due to the reuse of metal beams and savings from gravel procurement at product stage, and free dismantling and reduced on-site crushing at demolition stage.
Ally, J., Pryor, T.	2016	• Diesel, Natural Gas, Hybrid and Hydrogen Fuel Cell Bus systems • The Australian/New Zealand Standard for Life Cycle Costing (AS/NZ 4536:1999) was observed in the evaluation of the aforementioned technologies for the bus system. The findings turned out to be diesel buses in terms of total cost of ownership. The diesel−electric hybrid bus was 10% higher than that of the diesel bus but was young compared with the diesel bus. The hydrogen bus was similar to the hybrid, which was relatively younger than the diesel-powered bus.
Bengtsson, M., Kurdve, M.	2016	• Machining Equipment (with Dynamic Maintenance Cost in the Model) • Life cycle costing helped set the guidelines in determining the components to consider in designing or specifying an equipment. The results showed that in procuring machining equipment, operation man-time, energy use, maintenance and repair costs, downtime costs, process fluids, and chemicals are the factors to consider beside the functionality of the design in terms of short setup and changeover times.

Daylan, B., Ciliz, N.	2015	• Lignocellulosic Bioethanol as Alternative Fuel • Bioethanol blends [E10 and E85 (10% and 85% by volume of bioethanol with gasoline)] and conventional gasoline were compared. The findings yielded E85 to be most cost efficient, especially that driving cost is lower by 23% compared with conventional gas based on a 1-km driving distance.
Mohamad, R., Verrastro, V., Cardone, G., Bteich, M. R., Favia, M., Moretti, M., Roma, R.	2014	• Olive Agricultural Practices • The findings revealed the organic system to have higher net present value and internal rate of return, which implied higher profitability compared with the conventional way of growing olives. Good agricultural practices of electrically driven irrigation system, mechanical weeding and biological pest control, no tillage, or reduced tillage are the optimization options that reduce costs.
Rawal, N., Duggal, S. K.	2016	• Wastewater Treatment Units • Three technology options, including trickling filter system, waste stabilization pond, and activated sludge process, were evaluated. The waste stabilization pond technology had been found to be the most cost-effective in life cycle terms.

Ecosystem Metabolism (MuSIASEM) in the analysis of urban metabolism in Shanghai and Agnolucci et al. (2017) who have applied an instrumental variable approach. MuSIASEM is founded theoretically on Georgescu-Roegen's flow-fund models in bioeconomics, complex system theories, and hypercyclic and dissipative compartments theories in ecology (Lu et al., 2015). Agnollucci et al. (2017) have used the instrumental variable approach to address a failure in econometric estimation associated with the endogeneity of economic growth.

3.5 Tools for circular economy-environmental dimension

Online database search results for tools associated with environmental sustainability are unsurprisingly teeming in abundance for LCA. LCA is the most popular tool for analysis when it comes to CE and sustainability. It has been applied to various products, enterprises, and industries across the world in the interest of determining the environmental footprints specifically on land, air, and water and the choices and safety nets that can be put up to reduce the said footprints (Rebitzer et al., 2003; Roy et al., 2008; de Alvarenga et al., 2012; Astudillo et al., 2015; Eryuruk, 2015). Of the life cycle—based tools, LCA is the most standardized method, although it came out after life cycle costing or economic LCA. The standardization of the concept is based on ISO 14,000 series (Muthu, 2014) and is due to the huge stakeholders' interest on projecting environmental footprints concomitant with the production processes (Pennington et al., 2003).

Environmental footprints and thus environmental sustainability are under the domain of LCA. Accounting properly these footprints (e.g., water, Greenhouse gases (GHG), toxicity) will make product stakeholders aware of the burdens and pressures exerted on the environment due to the process of producing the product. However, indicators of these footprints vary according to the methods used in LCA. Muthu (2014) wrote extensively about LCA as applied in the textile industry particularly and had edited a book for the said subject as a matter of fact. In assessing the environmental footprints and impacts, he had identified Eco-indicator 99, CML 2001, EDIP 2003, EPS 2000, EPD 2007, Ecological Scarcity 2006, IMPACT 2002+, Recipe, TRACI, Ecological Scarcity Method, and some single indicator methods (ecological and carbon footprints) as the common life cycle impact methods used. These methods are actually linked to the software programs used in LCA, wherein the environmental footprints (e.g., GHG) can be assessed at midpoint (e.g., global warming) and/or at endpoint categories (e.g., climate change) that are important to be integrated and harmonized in a model/framework (Bare et al., 2000). Life cycle stages from cradle to grave, cradle to gate, or cradle to cradle provide the guide for the evaluation and attribution of the environmental impacts or footprints, which somehow eradicates the possibility of burden shifting.

Based on ISO, the general LCA process constitutes of goal and scope definition, life cycle inventory analysis, life cycle impact assessment, and life cycle interpretation (Muthu, 2014). The framework of LCA is shown in Fig. 3.2. As reported by Muthu (2014), each phase in Fig. 3.2 has crucial elements that guide the proper way in

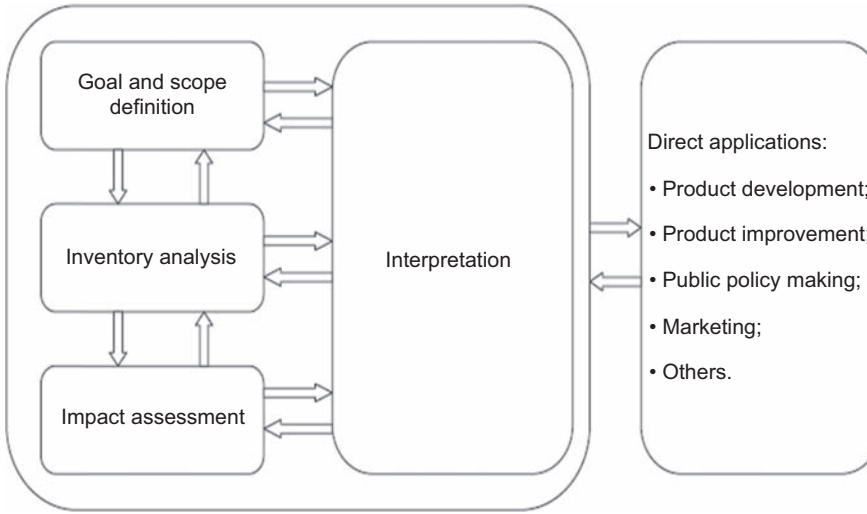


Figure 3.2 The life cycle assessment framework.
Muthu, S.S., 2014. Estimating the overall environmental impact of textile processing: life cycle assessment (LCA) of textile products. Assessing the Environmental Impact of Textiles and the Clothing Supply Chain, 105−131. https://doi.org/10.1533/9781782421122.105.

evaluating the footprints for environmental sustainability concerns. For instance, under goal and scope definition, questions to answer the intended applications, the intended audience, and the disclosure of the LCA report to the public are important to be addressed. Careful quantification of energy requirements, raw material needs, atmospheric emissions, waterborne emissions, emissions to land, solid wastes, and other emissions is under the care of life cycle inventory analysis. Choice of impact categories belongs to the phase of life cycle impact assessment with the classification, characterization, normalization, grouping, weighting, evaluating, and reporting the impact assessment results. LCA is a tedious, data-intensive process that is helpful to decision-makers and product stakeholders particularly in green product declaration (Muthu, 2014). Examples of LCA application on textiles are described in Table 3.2.

There are a number of advantages in using LCA to track the environmental burdens of products in the economy and to make informed choices and/or decisions regarding the consumption of products responsibly. LCA is a tool that allows decision-makers and stakeholders alike to realize the contributions of their actions (production and consumption) to the environment with proper accountability as life cycle stages of products provide a way of segmenting the environmental burdens for proper attribution.

3.6 Other environmental sustainability tools

Another relevant tool to assess environmental sustainability is the material flow analysis (MFA). Although not as popular as LCA, MFA is also a tool closely

Table 3.2 Studies showing the application of life cycle assessment (LCA) on textiles

Author/s	Year published	Topics and findings
Henry, B.K., Russell, S.J., Ledgard, S.F., Gollnow, S., Wiedemann, S.G., Nebel, B., Maslen, D., Swan, P.	2015	Wool Textiles and Clothing The complexity and diversity of wool textiles and apparel were unravelled throughout the life cycle. They have posed challenges in the analysis particularly in the allocation methods for the impacts and the resource use between coproducts. In the case study, the relative contributions of the two merino wool apparels were determined. The study evaluated not only the GHG emissions but also other impact categories such as energy demand and water use. New data for representative value chains are important in the use of LCA in future studies for more accurate results.
Astudillo, M.F., Thalwitz, G., Vollrath, F.	2015	Indian Silk Production Indian silk production is higher in environmental impacts than other fibers, which is accounted to the current production practices. Resource efficiency is emphasized in the new research direction. The role of government institutions are acknowledged in modernizing sericulture.
Baydar, G., Ciliz, N., Mammadov, A.	2015	Cotton Textile Products from Turkey Eco T-shirts were compared to the conventional shirts in terms of impacts to global warming, acidification, aquatic and terrestrial eutrophication, and photochemical ozone formation. The results revealed that the Eco T-shirts were eco-friendlier than the conventional shirts, having lower impacts across the impact categories considered. The use phase generated the most potential for global warming followed by cultivation, harvesting, and fabric processing phases. Use of sustainable raw materials, focus on consumer behavior, and sustainable practices in the use phase are recommended to be pursued.

Krishna Manda, B.M., Worell, E., Patel, M.K.	2015	Antibacterial T-shirt It was found that antibacterial shirts have better environmental performance in both cradle-to-gate and cradle-to-grave assessments due to lower contributions to climate change, freshwater toxicity, and eutrophication. Value creation opportunities are seen with the lower environmental impacts, lower costs, and lower risks. A producer's competitive advantage can be developed with the awareness of the consumers on the environmental footprints of the shirts they wish to buy.
Roos, S., Posner, S., Jönsson, C., Peters, G.M.	2015	Unbleached Cotton versus Bleached Cotton The study addressed the footprint of chemicals as an environmental burden in the said products. LCA is found to be more effective when chemical impacts are included.
Neiminen, E., Linke, M., Tobler, M., Beke, B.V.	2006	Environmental Product Declaration in Textiles LCA was used to develop criteria for the environmental product declaration in textile products. With the new technologies and R&D projects discovered in European textile processing, Action 628 will redefine the best available technology for the production and processing of selected textile products. It will also develop ecological impact indicators.

associated with the discourse on sustainability and CE. MFA is particularly an environmental management tool that deals with the analysis of material and energy input and output processes, resource use and stock calculations, and hotspot assessment (Zhang, 2013 as cited by Wang and Ma, 2017). It is used globally, particularly the material flow cost accounting (MFCA) that is more of an environmental than economic tool. MFA is noted to have been used in socioeconomic metabolism and industrial ecology studies to guide the policy formulation for effective environmental management (Patricio et al., 2015 as cited by Wang and Ma, 2017). The use of this tool relative to textile issues is observed in the study of Da Silva (2010), in which simulation results showed low hazardous wastes and the use of fossil fuel (gas oil) as a cause of the major environmental burden. The study is suggested for the reutilization of leftovers such as cotton fabric and paper, use of renewable energy, and investment in environmental conservation (Da Silva, 2010). The variant of MFA or MFCA is a tool for environmental sustainability that is aimed to find ways of reducing environmental burdens and costs. Its standards are based on ISO 14051 and MFCA is continuously fortified based on the concerns on the absence of theories behind the tool, lack of knowledge and application of the tool, the need for survey, interview, and statistical research methods, lack of systematic evidence in terms of applicability beyond manufacturing and in firm sizes, and complementarity with other tools (Christ and Burritt, 2014). Its use has not been observed yet in the analysis of the environmental burdens of textile production, although it can be applied when considered.

Some other tools are hybrids due to the integration of relevant tools such as agent-based modeling, systems dynamic modeling, and input−output modeling. Agent-based modeling explains a system's behavior by accounting the patterns, structure, behavior, and interactions in a system agent by agent (Macal and North, 2010). It is based on game theory, complexity science, and artificial intelligence research camps (Elsenbroich and Gilbert, 2014) and is widely used in many disciplines and/or areas of study (Macal and North, 2010). Systems dynamic modeling is closely associated with agent-based modeling, since it also deals with complex systems and system dynamics (Onat et al., 2016). It is appropriate for studies that are concerned with holistic outcomes considering the critical variables and links as well as feedback mechanisms in a system under study (Onat et al., 2016). The work of Onat et al. (2016) has demonstrated the potential contribution of the said modeling procedure in articulating the LCA tools for sustainability and in increasing the sensibility of policies to be recommended with the use of scenario analysis. Input−output modeling can also be integrated in LCA models, which can be used to analyze a supply chain based on global trade flows (Moran et al., 2014 as cited by Zamani et al., 2016). The work of Zamani et al. (2016) demonstrates the integration of both LCA and input−output models in identifying the hotspots of the clothing industry, which was noted with informative results. Indeed, there are many other hybrid tools that can be fused or integrated with LCA models and some other models associated with CE and sustainability. Their being hybrid models mean that they can be customized based on the research problems at hand and some computational requirements such as data availability and consistency.

3.7 Tools for circular economy-social dimension

For this part, social life cycle assessment (S-LCA) comes to mind easily. S-LCA is the latest or the most recent addition to the LCA methods, which is concerned on the social hotspots or impacts of a product or process over its life cycle (Lenzo et al., 2017). The United Nations Environment Programme-Society of Environmental Toxicology and Chemistry (UNEP-SETAC) had spearheaded the formulation of the guidelines for S-LCA methodology for social impact assessment (SIA) and had published these guidelines in the UNEP-SETAC Life Cycle Initiative website in 2009. It completes the triple bottom line framework of sustainability. The guidelines of the UNEP-SETAC suggest the consultation of stakeholders to be as inclusive as possible, covering the workers, the consumers, the local community, the society, and the value chain actors (Fan et al., 2015). There are no strict guidelines noticed so far as to the selection of the aforementioned stakeholders in terms of number and representativeness.

S-LCA can be used in a wide range of social concerns such as employment, politics, gender issues, women's rights, and human health that can be assessed carefully on either an individual or societal level (Finkbeiner et al., 2010). Examples of individual level of concerns as given by Finkbeiner et al. (2010) are protection and improvement of human health, achievement of a balanced settlement structure, and education, whereas societal level are identified with corporate social responsibility, size, and distribution of population. Because of S-LCA's infancy and methodological concerns (e.g., data availability and consistency), three indicators have been considered to be used to include human development index, Gini coefficient, and commitment to comply with the criteria of the UN Global Compact. However, the downside with these indicators is that it is difficult to relate them directly to products, thus the difficulty of integrating into product-based life cycle models (Finkbeiner et al., 2010). The use of S-LCA in textile's sustainability issues has not yet proliferated like the case of life cycle costing. However, recently a study published by Lenzo et al. (2017) has demonstrated the use of S-LCA in textile issues. The said work corroborates the limited application of S-LCA in tackling the sustainability issues in textiles. However, developments in the approaches used in S-LCA can help in handling the limited application of which in textiles. McCabe and Halog (2016) had proposed some innovations in the use of S-LCA to capture associated social hotspots, which include enhancing participatory approaches in systems thinking−based models.

3.8 Other tools

There are other tools that have been applied to evaluate social impacts. SIA is generally a methodology by itself as in the works of Esteves et al. (2017) on the human rights and risks of a project. There are many models of SIA and they can also be integrated into LCA, as links between SIA and LCA can be established easily with respect to the concerns of any research. In fact, Feschet et al. (2012) have demonstrated the fusion of SIA and LCA in their research in Cameroon concerning the

banana industry in the said country. Feschet et al. (2012) have designed a pathway for the assessment of social impacts with the Preston curve via the life cycle of producing bananas. Although the work of Feschet et al. (2012) can be classified as S-LCA in a way, the nonapplication of UNEP-SETAC guidelines makes it a hybrid of SIA and LCA more than not. Similar to LCA and its variants, SIA has also been applied in many products and economic activities across the world for sustainability issues.

3.9 Challenges and opportunities

Works on sustainability assessment are continuously evolving as improvements on the current tools are also undertaken continuously. In assessing sustainability on a life cycle basis, an integrated tool called life cycle sustainability assessment (LCSA) has been used. The aforementioned LCA tools (environmental, economic, and social) are integrated in LCSA to align with the three pillars of sustainability. From the first initiative of the German Oeko-Institut through product line analysis on to Kloepfer's formula in 2007, Finkbeiner et al. (2010) illustrated a strengthened LCSA as follows:

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{SLCA}$$

where: LCSA, life cycle sustainability assessment; LCA, life cycle assessment (environmental); LCC, life cycle costing (economic); SLCA, social life cycle assessment (social)

Until today, LCSA is an infant methodology, which is honed from time to time by sustainability scientists and researchers across the world to hurdle its computational issues and limitations (e.g., data availability, consistency, synthesizability, and reliability). Individually, the components of LCSA have their respective computational issues to resolve, as the use of the life cycle tools continues to increase. Muthu (2014) had reviewed LCA particularly in application to textiles and has noted some advantages and disadvantages in the use of which in environmental assessment processes (see Boxes 3.4 and 3.5). However, there is a general agreement about the issues with the tools in LCSA in which there is yet a lot to improve to address the requisites of computational integrity, particularly in obtaining sufficient data, standardized impact indicators, categories and methods, and most importantly, robust results. Such issues can be addressed somehow through computing-related innovations (e.g., data analytics, data mining, web-based databases, and cyber computing) because they can fill in some data gaps and deal with the complexities of large data analysis. Life cycle costing as a means to project investment outcomes (Akbar and Mokhtar, 2017) is inherently a comprehensive cost accounting where "noneconomic qualitative policy considerations" matter (Goh and Sun, 2015). Its constraints include among others the concerns on the cost in use, the responsibilities associated with financing capital and spending revenues, data sufficiency, basis of calculations, and appropriate discount rate (Bird, 1987 as cited by Goh and Sun, 2015). Heralova (2017) and Ilg

Box 3.4 Advantages of LCA

1. LCA can systematically analyze and address the environmental profile of a product from its raw material extraction stage through to the disposal stage using a holistic approach.
2. LCA can be used to compare different products or product systems as well as alternative processes to identify the best choice in terms of environmental impacts.
3. LCA is useful in quantifying the extraction of resources and emissions of a product system or process to air, water, and land and their associated impacts.
4. LCA can be used to identify hotspots in the life cycle of a product or for different production processes of a product system.
5. Based on the information supplied by LCA, LCIA, and hotspot analysis, it is viable for a manufacturer to reduce the environmental impacts of a product system or production processes.
6. LCA is a comprehensive tool as far as environmental interventions of a product system or process are concerned.
7. LCA is a viable tool to select the best waste management approach among different options.
8. LCA can offer clear business benefits such as follows:
   a. lower costs and increasing revenues
   b. brand enhancement and corporate image
   c. better market access
   d. quantitative basis for corporate sustainability
   e. enhanced customer relationships
9. LCA can be used as a tool for companies to evaluate their position in terms of sustainability, and based on LCA results they can define their sustainability goals.
10. LCA can be used to raise environmental awareness of employees, customers, and the public.
11. LCA studies are useful for public communication (eco-labelling of products, environmental product declarations, etc.).
12. LCA studies can be used in companies to establish performance and to manage risks within the supply chain.
13. LCA studies can be used for environmental reporting, green procurement, and regulatory compliance.
14. LCA studies can be employed for industrial benchmarking.

Muthu, S.S., 2014. Estimating the overall environmental impact of textile processing: life cycle assessment (LCA) of textile products. Assessing the Environmental Impact of Textiles and the Clothing Supply Chain, 105−131. https://doi.org/10.1533/9781782421122.105.

et al. (2016) pointed out similar limitations of life cycle costing as attributable to data constraints, lack of standards, and high uncertainty. Despite being a highly standardized method of life cycle evaluation, LCA (environmental) still faces the aforementioned limitations, only in degrees much lower than the other two counterparts (life cycle costing and social life cycle) because of the prior standardization initiatives, particularly by UNEP-SETAC.

Box 3.5 Disadvantages of LCA

1. An LCA study is very complex and highly data intensive.
2. LCA studies are performed using different assumptions and subjective valuation procedures.
3. LCA studies address only potential impacts, not actual impacts, and require a high degree of expertise.
4. The availability of quality data for LCA is problematic.
5. LCA studies address only environmental aspects of a product and not economic or social aspects of a product.
6. LCA cannot address localized impacts and it is a steady-state approach rather than a dynamic one.
7. LCA models focus principally on industrial activities and do not consider market mechanisms or secondary effects on technological development.
8. Results derived from a detailed LCA study are location specific and are not directly applicable to other locations.
9. Availability of relevant and up-to-date databases is a major issue.
10. Transparency may be lacking or perceived to be lacking.
11. LCA studies suffer uncertainties such as data uncertainty and uncertainty of models.
12. LCA has restrictions in its applicability as a decision support tool in planning waste management and policy making.

Muthu, S.S., 2014. Estimating the overall environmental impact of textile processing: life cycle assessment (LCA) of textile products. Assessing the Environmental Impact of Textiles and the Clothing Supply Chain, 105–131. https://doi.org/10.1533/9781782421122.105.

The social LCA is all the more laden with challenges associated with computational integrity. The UNEP-SETAC initiatives to standardize SLCA is the best thing that had happened in the pursuit of determining social impacts and hotpots (Benoît et al., 2010; Benoît-Norris et al., 2011), but some refinements are needed to improve further the results generated by the method. The issues mentioned by practitioners of the method across the world are as follows:

- Yet no standardized set of indicators (Finkbeiner et al., 2010)
- Around 150 social sustainability indicators addressing diverse social challenges that may pose difficulty in establishing a coherent and technically feasible approach in evaluating social sustainability (Finkbeiner et al., 2010; Jørgensen et al., 2009)
- Lacking indicators to address technology implementation issues (Lehmann et al., 2013)
- Data availability (Finkbeiner et al., 2010; Ekvall, 2010; Jeswani et al., 2009; Lehmann et al., 2013)
- The need to account the social performance of governments and other social aspects of the product origin (Ekvall, 2010)
- Subjective value systems (Hosseinijou et al., 2013; Ramirez et al., 2014)
- Database development, integration with other software programs, and effective communication of results are among the challenges (Hosseinijou et al., 2013)
- No consistent method of evaluating social impacts (Hsu et al., 2013)

- The nature of assessment is mostly qualitative (Jeswani et al., 2009)
- Non−site-specific data to contribute to poor attribution of impacts (Jeswani et al., 2009; Fan et al., 2015)
- Contextualizing the use of SLCA (Parent et al., 2012; Ramirez et al., 2014)
- Robustness of findings (Smith and Barling, 2014)
- Usage, acceptance, and time-sensitivity of data (Wu et al., 2014)

Integrating the three LCA methods would thus be complicated. Under the current setup of the said methods, harmonization would pose as a key challenge and long-term goal (Wu et al., 2014). With this, undertaking scientific rigors to standardize and harmonize the life cycle−based methods for ease of aggregation is inevitable. Having the aforementioned limitations is adequate to guide a great deal of work ahead to refine and standardize the methodologies associated with LCSA that is so aligned with the triple bottom-line framework of sustainability.

The other non−life cycle−based tools and/or methods discussed herein also have their own limitations. In part, these limitations have been mentioned in the preceding section, but in addition, industry and public awareness is important to convey accurately the meaning of results from MFCA (Nakajima et al., 2014). Dealing with unclear uncertainty ranges for stocks and flows (Rechberger et al., 2013; Wang and Ma, 2017) and MFA/MFCA not being integrated with the common enterprise resource planning systems and accounting tools (Schmidt, 2014) are among other things to resolve as well among the MFA and/or MFCA users to improve the precision of MFA and/or MFCA results. The rest of the tools, particularly the econometric approach, have to consider veering away from reductionist approaches, since sustainability is holistic in nature and so are its issues. Thus, much of the opportunities regarding the refinement of tools and methods for sustainability studies lies on the fundamental research to address the aforementioned limitations, especially on standardizing these tools and methods.

3.10 Sustainability assessment in the Philippine textile industry

In the Philippines, sustainability in the textile industry is an issue but it is not yet studied as holistically as following the triple bottom-line framework of people, economy, and the environment. Published reports on sustainability discussions are mostly about the socioeconomic performance of the said industry as in the works of Ofreneo (2009) and Sanchez (1990). However, the possibility of having efforts directed toward instituting sustainable industry practices for textiles to be continuing is not discounted at present. Particularly, the performance of the said industry had long been investigated with respect to their international counterparts (Sanchez, 1990) but had barely tackled sustainability implications of the industry performance, especially toward the environment, people, and the economy. Accounting the impacts of unsustainable practices in the textile industry from production to disposal can be found in the work of Waite (2009) (see Table 3.3 for the details of these impacts on people, economy, and the

Table 3.3 Impacts of the unsustainable practices in the textile industry

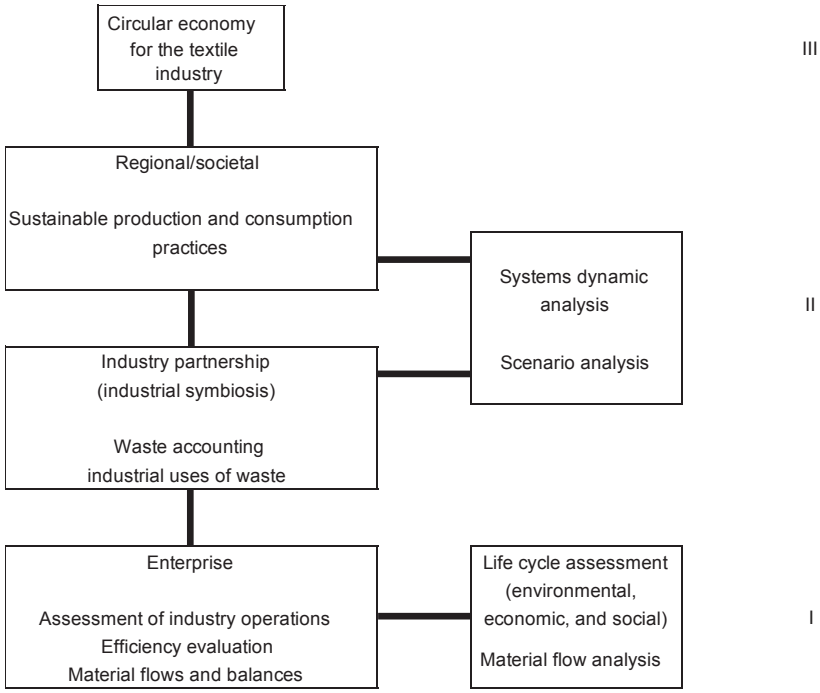
Type of impacts	Categories
Environmental	Contribution to climate change • Burning fossil fuels for (1) electricity needed in manufacturing, (2) agricultural machinery, and (3) laundering (electricity and heating water) Toxic chemicals • Fertilizers and pesticides in agriculture • Manufacturing stages such as fiber extraction, pretreatment, dyeing, and printing Waste volumes • Nonbiodegradable wastes to landfill • Large quantities of wastes because of "fast fashion" Water consumption • Extensive water use (such as in cotton crop cultivation) • Dramatic changes to local water resources Nonrenewable resources • Fossil fuels (coal, oil, gas) used as a main product in producing synthetic fibers and auxiliary chemicals Space consumption • Large fields for harvest can take away space needed for food production
Economic and social	Low wages • Legal minimum wage sometimes lower than realistic minimum living wage • Cycle of poverty Low labor standards • Poor working conditions (unsafe, long hours) • Child labor Low collective bargaining • Some countries do not grant the right to form unions Lack of fair trade • Subsidies and regulations prohibit fair trade of textiles

Allwood, Larsen et al., 2006 as cited by Waite, M., 2009. Sustainable textiles: the role of bamboo and a comparison of bamboo textile properties. Journal of Textile and Apparel, Technology and Management 6 (2), 1−21.

environment). The same has been also discussed in the work of Tomaney (2015) in the analysis of the textile industry based on environmental sustainability with the use of LCA.

With respect to the foregoing discussion, sustainability studies for textiles in the country have yet to catch up in terms of frameworks and methodologies. This also goes to say that contemplating for the application of CE strategies in textile industry practices has not yet sunk in, in spite of the accessible discourses on CE. Thus, there is a huge dearth for research on the aspects of evaluating the environmental, economic, and social impacts of textile production practices, especially that there are footprints from the textile industry of the country to control and manage efficiently. Any of the tools aforementioned can be used to examine the environmental, economic, and social sustainability footprints of the said industry. The way of doing it can be patterned after the framework suggested in the work of Balanay and Halog (2016) entitled Charting Policy Directions for Mining's Sustainability with Circular Economy wherein tiers of analysis are established on the basis of who must be involved necessarily. The first tier of which concerns the actions of an enterprise in an industry and the relevant tools for this include LCA and MFA. The goal for this tier is to determine the footprints and material balances of an enterprise in preparation for a bigger analysis concerning the second tier. The second tier refers to the industry-wide approaches to control and minimize unwanted footprints. It suggests exploring the possibilities of industrial symbiosis to manage the footprints. The third and final tier of analysis pertains to the analysis with respect to sustainable production and consumption policy support. The suggested method for this is the systems dynamic analysis to determine and assess the potential policies that can help institute sustainability and CE for the textile industry.

For the Philippine textile industry, the adoption of the aforementioned framework would require competencies to go about it. These competencies are aligned to concepts advocated in industrial ecology for CE wherein life cycle thinking, systems thinking, and strategies for sustainable production and consumption practices are at the core. In the analysis for ways to manage and design waste out in the textile industry, the framework suggested by Balanay and Halog (2016) is relevant to be followed as exhibited. Fig. 3.3 details the framework that also shows the sustainability roadmap for the textile industry. The framework shows the graduation of efforts to institute circularity and design out waste strategies in the textile industry. Stage I is the phase in which the scientific investigation on the efficiency of textile industry operations is carried out to determine the problem areas of the textile industry operations, which leave undesirable footprints to people, economy, and the environment. The footprints are accounted for in the search for waste minimizing strategies that the firms in the textile industry can undertake. The waste materials that cannot be controlled by the said strategies can be determined and analyzed for possible interventions anchored on industry partnerships or industrial symbiosis. In this way, wealth creation out of waste should be explored and analyzed over a macro scale. The macro-scale analysis of designing waste out and in enhancing efficiency in the process is the stage in which the policies to institute circularity strategies and sustainable production and consumption by the industry



Stage I: assessment of industry operations to determine the various footprints of the textile industry, material balances, and efficiency of resource use and waste minimization strategies
Stage II: determination of material balances, and waste materials and identification of industrial uses of waste, waste reutilization strategies, and sustainable production and consumption practices
Stage III: policy initiatives toward the development of circular economy for the textile industry

Figure 3.3 The framework and directions toward the development of circular economy for the textile industry.

stakeholders and the society will be developed, evaluated for their potential repercussions, piloted, and implemented.

The development of CE is indeed an arduous and complicated task to undertake so that footprints of industrial operations will be manageable. It concerns not only the business entities but also the entire gamut of stakeholders in the society to be effective. Thus, systems analysis is relevant for this aspect because of the need to do the evaluation holistically. With respect to the methodological challenges of using the relevant tools such as LCA and systems analysis, similar difficulty and constraints may be encountered, which the practitioners of the country can help improve. This somehow pursues the R&D directions for rehashing the methods toward the development of CE, particularly in projecting the chances of its success and the benefits of instituting it. While other countries such as China, Japan, Germany, and the Netherlands have been serious in launching CE for sustainable waste to wealth creation, the Philippines

can start doing it with its textile industry following the R&D needs and directions associated with the framework in Fig. 3.3 and taking policy actions from the said needs and directions to institutionalize the CE efforts.

3.11 Conclusion

Sustainability has challenged the scientific communities in equal measure to search for appropriate tools and methods that fit its holistic nature. This work has specifically examined the internet sources for research works on sustainability and CE across the world with emphasis on application in the textile industry to note the inventory of associated tools and methods. The findings have yielded astounding results as there are a number of researches that have been done already on matters associated with sustainability and CE particularly in textiles. Many of the research works have used varied approaches, but the choice of methods with which the approaches are used are distinctively adhering to the building blocks of CE, which relate to life cycle and systems thinking. LCA and its variants (life cycle costing and social LCA) are undeniably the popular methods in this context. Some of these methods are integrated to be holistic. However, it has been observed that the sustainability issues in the textile industry are tackled in fragments, discussing only an aspect or two in the triple bottom-line sustainability framework in spite of the integrated approaches and methods. A closer look at these methods and tools reveals the need to do a great deal of harmonization and standardization. Hence, methods and tools associated with sustainability and CE, particularly in the textile industry, are yet evolving and need fundamental research to hurdle their computational integrity issues. In the case of the Philippine textile industry, there is yet a need to catch up on this aspect, in which the framework suggested by Balanay and Halog (2016) originally suggested for the Philippine mining sector can be of help to start the initiatives toward sustainability and CE. The stages through which the said industry can go need to be founded on the science of industrial ecology and CE to make informed decisions on how to go about the development and establishment of "circular" initiatives up to the macro level to cut down inefficiency and design waste out. It is suggested that the research and development program for textile in the Philippines be focused on answering the science requirements of the suggested framework to achieve efficiency and circularity over a macro scale in due time.

References

Agnolucci, P., Flachenecker, F., Söderberg, M., 2017. The causal impact of economic growth on material use in Europe. Journal of Environmental Economics and Policy 1−18. https://doi.org/10.1080/21606544.2017.1325780.

Akbar, A., Mokhtar, A.A.B., 2017. Integrating life cycle costing (LCC) and life cycle assessment (LCA) model for selection of centralized chilled water generation-review paper. In: MATEC Web of Conferences, vol. 131. https://doi.org/10.1051/matecconf/201713104006, 04006.

Ally, J., Pryor, T., 2016. Life cycle costing of diesel, natural gas, hybrid and hydrogen fuel cell bus systems: an Australian case study. Energy Policy 94, 285–294.

Astudillo, M.F., Thalwitz, G., Vollrath, F., 2015. Life cycle assessment of silk production-a case study from India. Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing 255–274. https://doi.org/10.1016/B978-0-08-100169-1.00011-3.

Balanay, R., Halog, A., 2016. Charting policy directions for mining's sustainability with circular economy. Recycling 1 (2), 219–230.

Bare, J.C., Hofstetter, P., Pennington, D.W., Udo de Haes, H.A., 2000. Midpoints vs. endpoints: the sacrifices and benefits. International Journal of Life Cycle Assessment 5 (6), 319–326.

Baydar, G., Ciliz, N., Mammadov, A., 2015. Life cycle assessment of cotton textile products in Turkey. Resources, Conservation and Recycling 104, 213–223.

Bengtsson, M., Kurdve, M., 2016. Machining equipment life cycle costing model with dynamic maintenance cost. Procedia CIRP 48, 102–107.

Benoît, C., Norris, G.A., Valdivia, S., Ciroth, A., Moberg, A., Bos, U., Prakash, S., Ugaya, C., Beck, T., 2010. The guidelines for social life cycle assessment of products: just in time! International Journal of Life Cycle Assessment 15, 156–163.

Benoît-Norris, C., Vickery-Niederman, G., Valdivia, S., Franze, J., Traverso, M., Ciroth, A., Mazijn, B., 2011. Introducing the UNEP/SETAC methodological sheets for subcategories of social LCA. International Journal of Life Cycle Assessment 16, 682–690.

Christ, K.L., Burritt, R.L., 2014. Material flow cost accounting: a review and agenda for future research. Journal of Cleaner Production 108, 1378–1389.

CIRAIG., 2015. Circular Economy: A Critical Literature Review of Concepts. Available at: www.ciraig.org/pdf/CIRAIG_Circular_Economy_Literature_Review_Oct2015.pdf.

Da Silva, P.A.C., 2010. Simulation Environmental Analysis in the Manufacturing of Textile Products. Available at: https://repositorio-aberto-up.pt./handle/10216/65408.

Daylan, B., Ciliz, N., 2015. Life cycle assessment and environmental life cycle costing analysis of lignocellulosic bioethanol as an alternative transportation fuel. Renewable Energy 89, 578–587.

De Alvarenga, R.A.F., Galindro, B.M., Helpa, C.F., Soares, S.R., 2012. The recycling of oyster shells: an environmental analysis using life cycle assessment. Journal of Environmental Management 106, 102–109.

Ekvall, T., 2010. Nations in social LCA. International Journal of Life Cycle Assessment 16, 1–2.

Ellen MacArthur Foundation, 2013. Towards the Circular Economy. Available at: https://mvoederland.nl/system/files/media/towards-the-circular-economy.pdf.

Elsenbroich, C., Gilbert, N., 2014. Agent-based modelling. Modelling Norms 1–209. https://doi.org/10.1007/978-94-007-7052-2-4.

Eryuruk, S.H., 2015. Life cycle assessment method for environmental impact evaluation and certification systems for textiles and clothing. Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing 125–148. https://doi.org/10.1016/B978-0-08-100169-1.00007-1.

Esteves, A.M., Factor, G., Vanclay, F., Götzmann, N., Moreira, S., 2017. Adapting social impact assessment to address a project's human rights impacts and risks. Environmental Impact Assessment Review 67, 73–87.

Fan, Y., Wu, R., Chen, J., Apul, D., 2015. A review of social life cycle methodologies. In: Muthu, S. (Ed.), Social Life Cycle Assessment. Environmental Footprints and Eco-design of Products and Processes. Springer, Singapore. https://doi.org/10.1007/978-981-287-296-8-1.

Feschet, P., Macombe, C., Garrabé, M., Loeillet, D., Saez, A.R., Benhmad, F., 2012. Social impact assessment in LCA using the Preston pathway. International Journal of Life Cycle Assessment 18, 490–503.

Finkbeiner, M., Schau, E.M., Lehmann, A., Traverzo, M., 2010. Towards life cycle sustainability assessment. Sustainability 2, 3309−3322.

Goh, B.H., Sun, Y., 2015. The development of life cycle costing. Building Research and Information 1−15. https://doi.org/10.1080/09613218.2014.993566.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., Noble, I., 2013. Sustainable development goals for people and planet. Nature 495, 305−307.

Guinée, J.B., Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., de Koning, R., van Oers, L., Sleeswijk, A.W., Suh, S., Udo de Haes, H.A., de Bruijn, H., van Duin, R., Huijbregts, M.A.J., Lindeijer, E., Roorda, A.A.H., van der Ven, B.L., Weidema, B.P., 2004. Handbook on Life Cycle Assessment. Kluwer Academic Publishers, USA.

Hannouf, M., Assefa, G., 2016. Comments on the relevance of life cycle costing in sustainability assessment of product systems. International Journal of Life Cycle Assessment. https://doi.org/10.1007/s11367-016-1136-3.

Heijungs, R., Settani, E., Guinée, J.B., 2012. Toward a computational structure for life cycle sustainability analysis: unifying LCA and LCC. International Journal for Life Cycle Assessment 18, 1722−1733.

Henry, B.K., Russell, S.J., Ledgard, S.F., Gollnow, S., Wiedemann, S.G., Nebel, B., Maslen, D., Swan, P., 2015. LCA of wool textiles and clothing. Handbook of Life Cycle Assessment of Textiles and Clothing 217−254. https://doi.org/10.1016/B978-0-08-100169-1.00010-1.

Heralova, R.S., 2017. Life cycle costing as an important contribution to feasibility study in construction projects. Procedia Engineering 196, 565−570.

Hong, J., Zhou, J., Hong, J., Xu, X., 2011. Environmental and economic life cycle assessment of aluminum-silicon alloys production: a case study in China. Journal of Cleaner Production 24, 11−19.

Hosseinijou, S.A., Mansour, S., Shirazi, M.A., 2013. Social life cycle assessment for material selection: a case study of building materials. International Journal of Life Cycle Assessment 19, 620−645.

Hsu, C.-W., Wang, S.-W., Hu, A.H., 2013. Development of a new methodology for impact assessment of SLCA. In: 20th CIRP International Conference on Life Cycle Engineering. Singapore.

Hu, M., Miranda-Xicotentat, B., Ita-Nagy, D., Prado, V., Guinée, J., van Roekel, E., Huismans, R., Rens, F., Lotfi, S., Di Maio, F., 2017. Life cycle assessment and life cycle costing for demolition waste management. In: Di Maio, F., Lotfi, S., Bakker, M., Hu, M., Vahidi, A. (Eds.), HISER International Conference: Advances in Recycling and Management of Construction and Demolition Waste, 21-23 June. Delft University of Technology, Delft, The Netherlands, pp. 270−273.

Ilg, P., Hoehne, C., Guenther, E., 2015. High-performance materials in infrastructure: a review of applied life cycle costing and its drivers-the case of fiber-reinforced composites. Journal of Cleaner Production 112, 926−945. https://doi.org/10.1016/j.clepro.2015.07.051.

Jensen, A.A., Hoffman, L., Møller, B.T., Schmidt, A., Christiansen, K., Elkington, J., van Dijk, F., 1997. Life Cycle Assessment. Environmental Issues Series No. 6. European Environment Agency.

Jeswani, H.J., Azapagic, A., Schepelmann, P., Ritthoff, M., 2009. Options for broadening and deepening the LCA approaches. Journal of Cleaner Production 18, 120−127.

Jørgensen, A., Lai, L.C.H., Hauschild, M.Z., 2009. Assessing the validity of impact pathways for child labour and well-being in social life cycle assessment. International Journal of Life Cycle Assessment 15, 5−16.

Korhonen, J., Honkasalo, A., Seppälä, J., 2017. Circular economy: the concept and its limitations. Ecological Economics 143, 37−46.

Krishna Manda, B.M., Worell, E., Patel, M.K., 2015. Prospective life cycle assessment of an antibacterial T-shirt and supporting business decisions to create value. Resources, Conservation and Recycling 103, 47−57.

Kuhlman, T., Farrington, J., 2010. What is sustainability? Sustainability 2, 3436−3448.

Lehmann, A., Zschieschang, E., Traverso, M., Finkbeiner, M., Schebek, L., 2013. Social aspects for sustainability assessment of technologies-challenges for social life assessment (SLCA). International Journal of Life Cycle Assessment 18, 1581−1592.

Lenzo, P., Traverso, M., Salomone, R., Ioppolo, G., 2017. Social life cycle assessment in the textile sector: an Italian case study. Sustainability 9 (2092), 1−21.

Lu, Y., Nakicenovic, N., Visbeck, M., Stevance, A., 2015. Five priorities for the UN sustainable development goals. Nature 520, 432−433.

Macal, C.M., North, M.J., 2010. Tutorial on agent-based modelling and simulation. Journal of Simulation 4, 151−162.

Maia, L.C., Alves, A.C., Leão, C.P., 2012. Design of a lean methodology for an ergonomic and sustainable work environment in textile and garment industry. In: Proceedings of the ASME 2012 International Mechanical Engineering Congress and Exposition, 9−15 November 2012, Houston, Texas, USA.

McCabe, A., Halog, A., 2016. Exploring the potential of participatory systems thinking techniques in progressing SLCA. International Journal of Life Cycle Assessment. https://doi.org/10.1007/s11367-016-1143-4.

Mohamad, R., Verrastro, V., Cardone, G., Bteich, M.R., Favia, M., Moretti, M., Roma, R., 2014. Optimization of organic and conventional olive agricultural practices from a life cycle assessment and life cycle costing perspectives. Journal of Cleaner Production 70, 78−89.

Muthu, S.S., 2014. Estimating the overall environmental impact of textile processing: life cycle assessment (LCA) of textile products. Assessing the Environmental Impact of Textiles and the Clothing Supply Chain, 105−131. https://doi.org/10.1533/9781782421122.105.

Nakajima, M., Kimura, A., Wagner, B., 2014. Introduction of material flow cost accounting (MFCA) to the supply chain: a questionnaire study on the challenges of constructing a low-carbon supply chain to promote resource efficiency. Journal of Cleaner Production 108, 1302−1309.

Neiminen, E., Linke, M., Tobler, M., Beke, B.V., 2006. EU COST action 628: life cycle assessment (LCA) of textile products, eco-efficiency and definition of best available technology (BAT) of textile processing. Journal of Cleaner Production 15, 1259−1270.

Ofreneo, R., 2009. Development choices for the Philippine textiles and garments in the post-MFA era. Journal of Contemporary Asia 39 (4), 543−561.

Onat, N.C., Kucukvar, M., Tatari, O., Egilmez, G., 2016. Integration of system dynamics approach toward deepening and broadening the life cycle sustainability assessment framework: a case for electric vehicles. International Journal of Life Cycle Assessment 21, 1009−1034.

Parent, J., Cucuzzella, C., Revéret, J.-P., 2012. Revisiting the role of LCA and SLCA in the transition towards sustainable production and consumption. International Journal of Life Cycle Assessment 18, 1642−1652.

Pennington, D.W., Potting, J., Finnveden, G., Lindeijer, E., Jolliet, O., Rydberg, T., Rebitzer, G., 2003. Life cycle assessment part 2: current impact assessment practice. Environment International 30, 721−739.

Ramirez, P.K.S., Petti, L., Haberland, N.T., Ugaya, C.S.L., 2014. Subcategory assessment method for social life cycle assessment. part 1: methodological framework. International Journal of Life Cycle Assessment 19, 1515−1523.

Rawal, N., Duggal, S.K., 2016. Life cycle costing assessment-based approach for selection of wastewater treatment units. National Academy Science Letters. https://doi.org/10.1007/s40009-016-0429-1.

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W.P., Suh, S., Weidema, B.P., Pennington, D.W., 2003. Life cycle assessment part 1: framework, goal and scope definition, inventory analysis, and applications. Environmental International 30, 701−720.

Rechberger, H., Cencic, O., Frühwirth, R., 2013. Uncertainty in material flow analysis. Journal of Industrial Ecology 18 (2), 159−160.

Roos, S., Posner, S., Jönsson, C., Peters, G.M., 2015. Is unbleached cotton better than bleached? exploring the limits of life-cycle assessment in the textile sector. Clothing and Textiles Research Journal 33 (4), 231−247.

Roy, P., Nei, D., Orikasa, T., Xu, Q., Okadome, H., Nakamura, N., Shiina, T., 2008. A review of life cycle assessment (LCA) on some food products. Journal of Food Engineering 90, 1−10.

Sanchez, A., 1990. The textile industry in the Philippines and Thailand: a comparison. Journal of Philippine Development 17 (1), 67−87.

Schmidt, M., 2014. The interpretation and extension of material flow cost accounting (MFCA) in the context of environmental material flow analysis. Journal of Cleaner Production 108, 1310−1319.

SINCERE, 2015. Project SINCERE (Sino-European circular economy and resource efficiency). Available at: http://www.ucl.ac.uk/sincere/about.

Smith, J., Barling, D., 2014. Social impacts and life cycle assessment: proposals for methodological development for SMEs in the European food and drink sector. International Journal of Life Cycle Assessment 19, 944−949.

Steen, B., 2005. Environmental costs and benefits in life cycle costing. Management of Environmental Quality: An International Journal 16 (2), 107−118.

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sörlin, S., 2015. Planetary boundaries: guiding human development on a changing planet. Science 347 (6223), 1−17.

Tomaney, M., 2015. Sustainable textile production. Textile and Fashion. https://doi.org/10.1016/B978-1-84569-931-4.00022-2.

Waite, M., 2009. Sustainable textiles: the role of bamboo and a comparison of bamboo textile properties. Journal of Textile and Apparel, Technology and Management 6 (2), 1−21.

Wang, Y., Ma, H., 2017. Analysis of uncertainty in material flow analysis. Journal of Cleaner Production 170, 1017−1028.

Wu, R., Yan, D., Chen, J., 2014. Social life cycle assessment revisited. Sustainability 6, 4200−4226.

Zamani, B., Sandin, G., Svanström, M., Peters, G.M., 2016. Hotspot identification in the clothing industryusing social life cycle assessment-opportunities and challenges for input-output modelling. International Journal of Life Cycle Assessment 23 (3), 536−546. https://doi.org/10.1007/s11367-016-1113-x.

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3Rs and circular economy

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4.1 Introduction

In 1990, David W. Pearce and R. Turner first coined the term circular economy. The concept is becoming increasingly popular as a new way of thinking when doing business. It is a response to the insight that the present economy, relying on a linear take-make-waste system, is unsustainable and needs to be replaced by a circular system where waste is being transformed into new products and useful resources (Scott, 2015). A central idea is that we should consume services rather than products or become users rather than end consumers; hence business models should be designed in a way that makes us pay for the access to products rather than the ownership of the product. This will increase the incentives for producers to design high-quality products that last longer instead of products with short life time in order to make consumers quickly buy new ones. Another central idea is that the producers are responsible for the disposal and recycling of the product and hence they would get better incentives for designing in a way that facilitates the disassembling and recycling of the different materials or components (Van Ostaeyen et al., 2013).

Around 100,000 tonnes of used textiles were collected every year from Nordic States in the context of circular economy. Used garments from different regions are collected from the entry level to sale within the industry for coping up their charity welfare of the organization. Most exports are oriented toward the EU, Africa, and the Middle East in which 15% of total weight, reuse with low quality are sold to Asia. Most of the raw materials are taken for 10% reuse for industrial wipes, 8% for recycling, and 8% for incineration (Scott, 2015). The textile market price falls significantly due to increase in supply of used textiles in the coming years. Most of the resellers increased their production by adopting reusing concepts and also replaced the use of plastics at the cheapest price. Many researchers proved that the introduction of circular economic principles provided a superior solution toward the societal and environmental impact. The circular economic practices have led the industry toward an annual savings of around 193,000 tonnes by eliminating CO_2 and 72 million cubic meters of water, which has significantly contributed for the value chain of textile and apparel production (Van Ostaeyen et al., 2013).

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00004-2

4.2 Linear economy versus circular economy

"Take-make-dispose" is the stepping plan toward meeting out the targets of linear economy. Extracting the resources and producing the product is the need of the hour (Dillinger, 2016). The developed products are utilized until they are discarded and disposed as waste. The value is created in the textile supply chain by the maximum utilization and selling of the produced product to the fullest extent. The extraction of the raw material is reduced to the maximum wherever possible and after discarding a product, materials and parts are recycled. In a circular economy, value of the product is defined by focusing on the concept of value retention (Subramanian SenthilKannan, 2017a).

Using the sustainable approach of linear economy, the eco-efficiency of the product is improved. This ultimately results in the reduction of environmental impact and also leads to economic welfare. The negative effects are nullified in the context of linear economy. But in the sustainable approach of circular economy, the eco-efficiency is improved by concentrating on the system. Thus, the major focus in circular economy is to cut down the negative impacts prevailing in the system and to concentrate on maximizing the positive impact of the system by radical innovations and system change. The dissipation tendency of matters may lead to serious value losses. As the degree of order decreases (entropy increases), quality of the raw materials and overall energy of the system gets affected.

There will always be a value loss in localizing, separating, and melting the gold out of the microchips into one pure stream of gold. The process normally increases the risk of material loss, decreases the quality, and affects the functionality of the material as well as increase in money and labor. Hence, it is not possible to create a 100% circular economy and also not necessitating that the economy should be linear in stringent. In the present circular economic model, most of the elements have already been made as circular. It normally includes reduction in raw material extraction, increase in recycling process, changes in business models from product to service, and different roués for financing the same. The demand and speed for new input is obviously reduced in circular economy by the circulation of matter and energy (Subramanian SenthilKannan, 2017b).

In 2010, Ellen McArthur (Ellen MacArthur Foundation, 2014) paved steps to promote circular economy and inspire people and business to think in new ways and start shifting from linearity to circularity in the way they do business. In the context of industrial economy is still characterized by a linear model of consumption: companies extract materials, add labor and energy, and sell it to consumers who dispose of it after a short while, when it no longer serves its purpose or has just gone out of fashion. This can be called a take-make-dispose model. In general circularity requires 12 holistic approaches to define and apply to raw materials, energy, and the use of chemicals as well, and hence it also involves renewable energy (burning of fossil fuels is a linear activity since the recreation of oil, coal, and gas is basically nonexistent). Chemicals should preferably be nontoxic and within closed technical loops (Dillinger, 2016).

For instance, by keeping materials within loops, less primary production of the same material will be needed, and all upstream environmental impacts in the supply

chain of that material will decrease. By keeping chemicals in closed technical cycles, it is not necessary to increase concentrations of pollutants in nature. If more systems were transformed from linearity to circularity, the development toward a future within the frames of sustainability would be facilitated (Rupp, 2008).

4.3 Principles of circular economy

McKinsey (Bismar, 2017) has stated five major principles of circular economy which includes the following:

- Design out waste
- Build resilience through diversity
- Rely on energy from renewables
- Think in system
- Waste management

Waste management is the major need of the hour in lieu of circular economy is concerned. The 3R waste management approach addressed in circular economy governs the following: Reduce, Reuse, and Recycle and also it addresses the 4R which includes, Reduce, Reuse, Recycle, and Recovery (Subramanian SenthilKannan, 2017b). The product is disposed in the landfill which leads to the wastage of residual energy, but when incinerated a small portion is accounted for reuse. If it is further recycled, energy in the system is recovered. The following are a few terms and concepts used within the context of circular economy.

4.3.1 Cradle to cradle

According to Michael Braungart, the old concept stated as cradle to grave in the linear approach is opposed by the cradle to cradle (C2C) in terms of circular economy. Both William McDonough and Michael Braungart have published concepts related to the C2C approach, which is nothing but "remaking the way we make things." Furthermore, they have also evolved the concept and broadened their idea in refining the same and started a new business venture named McDonough Braungart Design Chemistry (MBDC) that helps companies implementing the C2C concept in their business. It would imply making new yarn out of old fibers to create innovative textile products in context with textile and apparel business.

Climatex fabric from the Swiss company Rohner Textile AG is an industrial example of this system. By preserving our nature in every way possible, we can foster sustainable industrial system supporting a triple bottom line of sustainability: people, planet, and profit. The C2C production system maintains the philosophy that no materials will be wasted at the end of the cycle; it will rather initiate nourishment for the next production process.

The fundamentals of C2C approaches are as follows:

1. Product design would give birth to new life for a used product. For instance, in nature, there is no wastage. As the leaf ends its life, it may drop out at fall, producing nourishment for

microorganisms. Those microorganisms would provide soil fertility which gives nourishment to the plants. Hence, there is always a closed loop system. The loop is not open, starting from one point and ending in another point. As such, C2C promotes product design in which the constituent materials can be retraced for another product.

2. Industries will be designed in a way so that it can utilize renewable sources like air, water, and sunlight to reduce the dependency on energy coming from nonrenewable sources.

4.3.2 Upcycling and downcycling

Recycling is divided into upcycling and downcycling. Upcycling is nothing but in which a product cycle is modified or converted to a new product life cycle of the same or higher quality, as opposed to recycling. But it is vice versa in case of downcycling. It is nothing but breaking down a product to its basic material and creating a new product, usually with lower quality than the original product (Armstrong et al., 2015). The "make do and mend" approach is either extending the useful life of an item or product; for example, by darning some old wool socks or reusing a material or product or giving it another function, such as turning old curtains into a garment. By upcycling textiles in this way, we can offer garments a second life and prevent them from ending up in landfill. Upcycling refers to reuse of a garment where its quality remains the same or is increased by the process, attempting to counter the common problem of recycling practices, reducing the quality of the original materials, as occurs when glass is recycled.

According to H & M, downcycling of natural fibers like cotton and wool is currently the most scalable recycling technology for postconsumer textiles, but the result is shorter textile fibers of a lower quality to virgin fibers. To increase quality, recycled fibers must be blended with virgin fibers. When it comes to upcycling, only polyester and certain nylons can currently be reprocessed. However, new technologies are being developed and cotton could be up next. For example, Evrnu is working on the upcycling process of converting cotton scraps into new manufactured cellulosic yarn.

4.3.3 Displacement effect

Displacement effect is related to neither textiles nor garments that will not be bought or produced as a result of efficient use of existing things. For example, Rent-a-Plagg international company has rented 513 garments in the last year, out of which approximately 271 avoided purchases of single garments had been made. How then do they contribute in making the clothing business more sustainable? For this case, the number of avoided purchases does not answer that question. Some studies make no distinction between avoided purchase and avoided production, but in order not to overestimate the environmental benefits of any business model, the best approach is the displacement effect. Displacement effect of avoided purchase does not necessarily mean the same thing as avoided production. Avoided production of clothes is a result of other clothes being efficiently used, and purchased clothes can also be efficiently used. Hence it has

to do with the utilization of clothes, or MIPS (Material Input Per Service) unit. The more service units, the lower the MIPS value. The lower MIPS value due to increased number of service units, the bigger the displacement effect of produced clothes.

Rent-a-Plagg company is therefore making the clothing business more sustainable only if it actually increases the utilization of clothes. The ownership in itself does not matter; it is nothing but how much the garment is utilized, number of service units accountable for lowering the MIPS value of the product, and also the cause for the displacement effect of clothes that are not used as well as not produced as a result.

4.3.4 Ecological footprint

In the ecosystem, ecological footprint is often compared with biocapacity of the system, which is a measure of human impact. This clearly implies the big picture of human overconsumption. In general, human beings are consuming natural resources as if they had 15 planets, Europeans are consuming as if they had 3 planets, and in the consumption race, the United States won with no less than 5 planets in the global scenario. Ecological footprint values are segregated into different segments and demands which include carbon, food, housing, and different environmental problems, such as climate change and water scarcity.

4.3.5 Waste hierarchy

In order to minimize and control the waste, waste hierarchy is the stepping stone in which actions are taken with respect to energy efficiency principles and effective utilization of natural resources (European Commission, 2017). It is nothing but forecasting on the development of sustainable waste management practices. The practices exist in different forms and can be formulated in a slightly modified approach (Nike, 2016). The most common waste hierarchy ranging from the most preferable to the least preferable is as follows:

1. Reduce/avoid creation of waste
2. Reuse
3. Recycle
4. Energy recovery
5. Disposal

4.4 Selected best practices in the apparel industry toward circular economy

4.4.1 Sustainable design in apparels

Circularity can and should be applied at different stages in the life cycle of clothes to either minimize resource flows or put resources in loops. All stages of the waste hierarchy should be worked with to avoid creation of waste and reuse by displacement effect in avoided production, making the clothes be reused over and over again.

Saiboo works with the third step, recycle, which is also very important since there will unavoidably be clothes that are disposed sooner or later, cannot be reused forever, and some clothes, like work wear in this case, lack secondhand value. Since resource scarcity is here to stay, circular economy seems to be inevitable; companies cannot afford being wasteful, both due to material costs and for their brand image. In the future companies cannot afford a bad reputation as a company that does not care about shifting their business toward sustainable practices and resource management. Circular economy business models are something that we will see more of, both in the clothing sector and other sectors.

In 2016, Levi Strauss and Evrnu developed the first pair of jeans using postconsumer cotton waste. In this technology, they have converted the consumer waste into renewable fibers using 98% less water than virgin cotton production.

G-Star Raw for the Oceans has developed the world's first denim collection made from recycling plastic waste. G-Star Raw on collaboration with Pharrell Williams designed a trailblazing denim collection from recycled plastic waste and named it as Bionic Yarn. An illustrated squid is used as the motif to represent the range and features of their collections along with positive slogans and messages to promote the same (Dillinger, 2016).

MUD Jeans is another company which also focuses on the design of garments using the circular model. Denims are leased to consumers for a monthly rental and then taken back after its complete usage. Discarded denims are shredded and blended with virgin cotton to make innovative fancy denims. Returned denims are also upcycled and sold as a unique vintage pair with personal names inscribed inside the garment giving a significant satisfaction toward the purchase of the same. Buttons and accessories sewn to the garment could also be reused in the near future (Adriaanse et al., 1997).

4.4.2 Sustainable fibers—a viable alternative

There are abundant categories of sustainable fibers in use, which include the following:

- **Natural fibers**—cotton, wool, silk, hemp/ramie/jute, bamboo, corn/soybean, pineapple, lyocell, Tencel, Lycra, banana, etc.
- **Recycled fibers**—recycled cotton and recycled PET

4.4.2.1 Silk

Natural silk is made from the cocoons of wild and semiwild silk moths of India and China. In its production, the pupae are not killed to obtain reeled yarn, but the open-ended cocoons are spun into yarn. Better properties like higher degree of fiber purity, improved yarn luster, and better uniformity than normal spun silk is achieved using organic silk. Since the fiber is spun, it has better fiber strength and durability.

4.4.2.2 Hemp

Hemp is the world's oldest and strongest natural textile fiber cultivated on earth. Few pesticides or fertilizers are used, and the fiber is sustainable by nature. Hemp grows

well in a wide variety of climates and soils. It requires far less fertilizers and pesticides than most commercial crops. It is economical and an eco-friendly substitute for linen and also a substitute of cotton for heavyweight products like tops, bottoms, jackets, and outerwear and denims. The US government produced the movie Hemp for victory to encourage farmers to grow hemp. The extraordinary qualities achieved by hemp include conditioning soil, clearing noxious weeds, three times the tensile strength of cotton, stain resistant, mold and bacteria resistant, moth and silverfish resistant, fire and heat resistant. Hemp retting—a softening procedure in ground—does not exhaust the fertility of the soil. Today industrial hemp is cultivated in the United States, Canada, China, Russia, Hungary, Germany, the Netherlands, France, Spain, England, Poland, and many other Eastern European countries. Around 30 different spinning mills in the United States offer a market for raw hemp fiber (Subramanian SenthilKannan, 2017b).

4.4.2.3 Wool

Using a 100% transparent method of production, preconsumer waste fabric and fibers (mostly wool) are collected and remanufactured into new material. Brands and retailers interested in integrating this system into their business model can reuse their own textile waste as raw material. This process has the potential to create an almost zero waste cycle of sourcing for brands that implement it. Not only is it a more economical production method, but the greater connection with textile mills from creating a circular economy is an opportunity for brands to have more involvement with the design of the fabrics resulting in greater exclusivity and improved innovation. Reverso with the partnership of Gucci collaborated on cashmere for autumn-winter 2015 men's wear. Wool and the Gang and Katie Jones are two UK-based sustainable knitwear brands in which they incorporate woolen yarns developed using shredded cotton textile waste such as old t-shirts to design eco-friendly knitwear (Adriaanse et al., 1997).

4.4.2.4 Recycled cotton

Recycled cotton is an eco-friendly choice for cotton clothing. Recycled cotton is a fabric which is made from recovered cotton that would otherwise be cast off during the spinning, weaving, or cutting process. The discarded cotton waste is collected, shredded into small fibers, and processed again into yarns and fabrics. It provides comfort and also helps in generating employment and fruitful resource for the preservation of our environment. No certification is mandatory; however, OEKO-TEX certification adds credibility and authentication (Subramanian SenthilKannan, 2017b). Levi's has recently started working on the development of massive clothing utilizing 20% recycled cotton in a garment. The company has experimented blending recycled fibers with long-staple fibers to solve environmental issues. But it has not come up with a large-scale solution to bring total change in the revolution of the industry. H & M is another company which has explored the use of recycled cotton in their production to create a fast fashion brand in their textile supply chain.

4.4.2.5 Recycled polyester

Polyester is one of the most nonbiodegradable polymers creating environmental problems. In 1993, Wellman, Inc. introduced the first polyester textile fiber made from postconsumer PET packaging with the trade names Fortrel and EcoSpun. The fiber is suitable for manufacturing a range of diversified products such as backpacks, blankets, T-shirts, sportswear, soft luggage, and socks. Patagonia is recently working on this recycled polyester in their business models to promote circular economy. Nau is another US-based company who is also working on the same.

Recycled polyester is dramatically better for the climate, creating 75% less CO_2 emissions than virgin polyester. This is due to the fact that recycled polyester does not require new petroleum to create, lowering the demand for new petroleum extraction and reducing our overall carbon footprint. It also provides a use for postconsumer and postindustrial polyester; it helps keep waste out of landfills. Considering the above fact and since polyester accounts for approximately 60% of the world's production, which is about twice the usage of plastic bottles, recycled polyester will provide a nonvirgin supply chain for polyester fiber and also has the potential to massively impact global energy and resource requirements.

4.5 Sustainable designs in sportswear

Several sportswear brands are moving ahead with innovative techniques to minimize the waste during its production. Since 2010, around three billion plastic bottles have been diverted from landfills to make footwear products. Waterless technology introduced in companies helps to color the fabric using zero water, saving nearly about 20 million liters of water. The renowned company Nike as of now is concentrating toward zero waste (Nike, 2013). Recycled and regenerated products are produced from the natural source of raw materials. Flyknit technology improved design and functionality produces 60% less waste than the traditional cut and sew method. Since 2012, the technology has reduced nearly 3.5 million pounds of waste (Nike, 2016).

Adidas has developed a product made with 95% recycled ocean plastic recovered near the Maldives. The major goal of the company is to produce 1 million pairs of the trainers from 11 million plastic bottles. Their target is to eliminate virgin plastic from its supply chain. A concept shoe is being developed from Biosteel fiber, which replicates natural silk and is completely biodegradable. Davy J, a new swimwear brand, has been designed and developed to prove that it is possible to produce competitive products using a sustainable approach. This will support circular economy using 100% regenerated nylon yarn from consumer waste including waste fishing nets. A tonne of waste generated is recovered and reused to produce more than 10,000 nylon swimsuits (Lo et al., 2012).

4.6 Sustainable apparels using zero waste

The major difference between circular economy and zero waste is that both the terminologies focus on eliminating waste and maximizing the use of natural resources. From ancient years, zero waste fashion has been a niche market. A new design

innovation with new demands will create low waste production and more sustainable practices. Methods include embellishing cutoff waste pieces into the design of the garment, weaving and knitting waste fabrics to form garments, zero waste pattern cutting, using ethical fabrics, and upcycling and embroidering pieces of waste fabric together to make whole pattern pieces. Budding designers need to be given the opportunity at an undergraduate level to experiment with new ways of producing and designing more sustainably. Zero waste fashion design addresses inefficiency in fabric use by reframing fabric waste as an opportunity to explore the magic of fashion; just like all fashion, zero waste fashion celebrates experimentation and the discovery of new forms.

Marks & Spencer (M & S) operated stores, offices, and warehouses in the United Kingdom and the Republic of Ireland producing around 83,000 tonnes of waste, all of which is valued and retained in the economy in some form. The majority is either transit packaging, such as cardboard and polythene, or unsold food which cannot be donated to charities. The small amount of damaged or impact clothing generated in their stores is donated to Oxfam or Newlife. Their goal is to ensure that operational waste is not led to landfill and have been working hard to reduce the waste and also continually improving their approach in fitting out their stores by seeking ways to reuse and refurbish equipment (Kering, 2016).

According to an estimate, the used products and packages from customer generates over 400,000 tonnes of materials with just over half likely to be reused or recycled. The remainder will be sent to some form of municipal disposal. According to the market share, 100,000 tonnes of clothing produced in M & S would be reused or recycled.

4.7 Cleaner production and waste management

The level of preventing or minimizing the generation of wastes or emissions is done by cleaner production. The basic idea of cleaner production is that it makes more sense to avoid creating a problem altogether, rather than trying to remedy the problem. It is commonly called as the proactive method of waste management (DeWinter, 2014). To achieve effective sustaining and self-sustaining by cleaner production, it is necessary to adopt a structured approach in targeted units/sectors. A structured approach means assigning responsibility, fixing targets, reviewing progress, and timely implementation of techno-economically feasible selected and agreed solutions for the industry. Cleaner production has been described as the continuous application of an integrated preventive environmental strategy to process products in order to reduce risks to humans and the environment.

As applied to the production process, it includes conserving raw materials and energy, eliminating toxic chemicals, and reducing the quantity and toxicity of all wastes and emissions before they leave the process; and as applied to products, it involves reducing environmental impacts all along the life cycle of the product. Waste reduction at the source, recycling, and product modification are the strategies

followed for achieving cleaner production in apparel industries. Waste reduction at the source includes good housekeeping and process change options (Adriaanse et al., 1997).

In a similar way, waste also directly hits your bottom line. Investment on money, time, and effort without increasing the value of your products or generating revenue is of no benefit. Surplus amount could be saved by proper control over the waste. Many manufacturers accept waste as a normal cost of business. Previous research has proven that waste should be optimized at every step of the manufacturing process, from sample making, material receiving, and inventory, through cutting/knitting, sewing/linking, and finishing, to packing (Institute for Environmental Studies).

The following are some findings:

1. Sample production waste:
   a. Mistakes in design communication
   b. Craftsmanship problems
2. Cutting floor waste:
   a. Wrong color or shade
   b. Fabric faults
3. Sewing department waste:
   a. Machine problems
   b. Faulty craftsmanship
4. Outsourcing waste:
   a. Dying
   b. Embroidery
5. Problems detected during final inspection:
   a. Ironing problems
   b. Measurement problems

The methods to control the waste in garment factories could be achieved by adopting the following strategies:

1. Commit to achieve a high-quality product and customer satisfaction.
2. Aim to identify and eliminate product defects.
3. Design a process to address all quality problems at every step of production.
4. Analyze and implement methodology to improve the quality.

If every stage in the production of a garment is executed correctly, the end result will be perfect. The best way to achieve it is to identify each fault, determine its cause, and find a way to prevent recurrences. It is essential, therefore, to maintain a quality history of each garment from the moment it is "born" raw, starting from the moment the materials arrive at your factory to the moment the customer inspects and approves the finished garments (Kering, 2016). As soon as the raw material enters the department, a proper quality check should be carried out to ensure that imperfect pieces do not continue along the production line to increase your wastage problem. Additional waste could be ensured where the operators are not skilled enough to operate sewing machines.

Quality gateway in preproduction: As material arrives, the laboratory test information generates a report and passes an alert to prevent the batch from going

into production if the failure rate is too high. The system also records the failure rate of the particular supplier, providing a guide for future sourcing. The receiving department passes the material to inventory.

Quality gateway on the production line: Before the pieces are put onto the sewing floor, it will be recorded for the inspection, including any fabric defects or errors in the cutting and also the rate of failure and its source. The fabric cut pieces are then passed in bundles to the sewing line, where each and every bundle tickets are scanned and the details recorded into the system.

Quality gateway in the final inspection: The semifinished garments which are ready for the finishing department provides a complete quality history for each garment. The defects could be identified easily and also the reason for the cause and the responsible person could be analyzed, and it helps in the formulation of a strategy to eliminate them at their source.

The concepts of TQM, ERP, and Six Sigma Quality system in garment factories have proven consistent results and also infers that information is a key factor in the QC process. Ecological consciousness and increased environmental awareness are growing steadily worldwide among apparel manufacturers, retailers, and consumers, who are all being encouraged to recycle and buy products made from recycled materials. The most popular global approach to waste management seems to culminate in the 3Rs: reduce, reuse, and recycle; however, it also refers to the 7Rs, with the addition of the concepts of regulations, recovering, rethinking, and renovation (Briceno and Stagl, 2006). Globally, many of the bigger textile and apparel manufacturers are starting to take an environmental awareness position in the market. Incentives for recycling include savings on resources and their costs, reduction of waste, savings with respect to land filling, and creation of jobs. The apparel industry has been identified as the fastest growing waste recycling concern across the country, and processes to encourage public participation and improved education have been some of the industry's key issues (Ellen MacArthur Foundation, 2014).

4.8 Recycling of textiles

Textile recycling is the process by which old clothing and other textiles are recovered for reuse or material recovery. Recycling is a dynamic process and, as markets become saturated with specific products such as wiping cloths and mop heads, new products must be developed and introduced. Clothing and textiles are nearly 100% recyclable. The importance of recycling textiles and apparel is increasingly being recognized. Furthermore, special equipment is, for instance, necessary to shred fabrics, to separate waste, and to extract fibers (Wang, 2006).

The textile industry is among the most essential consumer goods based sector. The textile and fashion industry is built on a "Take, make, consume, dispose" pattern of growth. The textile industry is among the most essential consumer goods industry. However, it is also accused of being one of the most polluting industries, where not only production but also consumption of textile produces waste. Every year consumers

throw away tonnes of usable textiles, including clothing, footwear, belts, hats, handbags, towels, rugs, sheets, and other linens. Almost 95% of this material can be reused as clothing and wiping cloths or recycled into new fiber-based products. Nothing in the textiles and apparel industry should be wasted (Selly, 2003). To counter the problem, the textile industry has taken measures for reducing its negative contribution toward the environment—one of which is textile recycling. Upcycling of textile goods is economically beneficial, yet much of the discarded clothing and textile waste.

4.8.1 Significant findings behind the need for recycling processes

The resources on this planet are ultimately finite. The two key fibers in the textile industry are cotton and polyester, which represent over 85% of global fiber production. Cotton relies on a finite land mass for agriculture and competes with food production. Polyester relies on finite sources of oil (petroleum based) and its extraction is damaging to the environment. In 2014, the global production of polyester filaments and cotton fiber was approximately 65 million tonnes, but this number is estimated to grow in upcoming years; with growing population demand and an increasingly unstable climate, we are not only facing global textile resource scarcity but also the hazardous environmental impact of textile fiber production. Therefore, effective resource management is now becoming a high priority in the industry (Wang, 2006).

Environmental issues are also associated with the sector, which includes high energy consumption in terms of water and application of toxic chemicals. Synthetic fiber products will not decompose in the landfills. Since last decades, decomposing such waste discarded in landfills has no resale value and it obviously pollutes the atmosphere; if not degraded, they get accumulated and spread infectious diseases and a foul smell. Woolen garments do decompose, but they also produce methane gas, which contributes to global warming (Selly, 2003).

4.9 3Rs and their implications in textiles and fashion

In 2010 an estimated £238−£249 million of reusable or recyclable textiles were discarded through kerbside residual waste collections. Recovering just 10% of this would generate a potential sales value of almost £25 million. Circular Economy Textiles for clothing the processes from raw material to garment supply contribute around one-third of the waste footprint, three-quarters of the carbon impact, and most of the water footprint (Rupp, 2008).

WRAP leads the Sustainable Clothing Action Plan which aims to improve the sustainability of clothing and textiles across its life cycle by looking at procurement and specification of lower impact fibers; designing clothes to increase their useful life and reduce laundry impacts; working with supply chain partners to increase

efficiency; and providing consumer information on garment longevity and laundry practice and reuse and recycling (Louis, 2012).

WRAP estimates that between 2.5 and 2.7 million tonnes of household textiles, clothing, footwear, and other textiles products like carpets and mattresses are consumed annually in the UK. In 2010 an estimated £238−£249 million of reusable or recyclable textiles were discarded through kerbside residual waste collections. Recovering just 10% of this would generate a potential sales value of almost £25 million. For clothing the processes from raw material to garment supply contribute around one-third of the waste footprint, three-quarters of the carbon impact and most of the water footprint (http://www.ethicalfashion).

SCAP aims to improve the sustainability of clothing and textiles across its life cycle by looking at procurement and specification of lower impact fibers; designing clothes to increase theirv useful life and reduce laundry impacts; working with supply chain partners tov increase efficiency; and providing consumer information onv garment longevity and laundry practice and reuse and recycling. For clothing, the most significant opportunity to save money and resources is to increase active life (Gardetti and Torres, 2013).

The Reusable Fabric Bank structure of São Paulo (BTR) was created in January 2015 with the objective of extending the life of stopped fabrics, stockpiles, clothes cuts leftovers, or small rolls of fabric and scraps, enabling them to circulate again, extending its life cycle through new uses, and preventing it from ending up in landfills. The fabrics to be reused are taken to the units and are organized and sanitized. After this process, they are put up for sale and marketed per kilo to the current value of R$ 45. In case of user deposits, fabrics against the reception of five credits on each kilo will be deposited and new credits can be taken for the purchase of another set of fabrics. The store's inventory capacity is 1.3 tonnes and this stock has already been renewed about 4 times, so it is estimated that more than 5 tonnes of fabric have already been reused in just one operation year of the business. Currently, Reuse Fabric Bank operates with more than 200 users (account holders) who simultaneously deposit and take fabrics. The users' profiles are small artisans, young designers, renowned stylists, companies that make a more personalized work with the fabrics, and even brands recognized for sustainable jobs (Textile sustainability, 2017).

4.10 Reduction of carbon footprints in apparel industries

Various ways and methods for reducing the carbon footprint during textile processing have been reported and widely published. Commercially viable products are available in the market and being supplied by many organizations. Some of the major areas of work are as follows:

1. Machinery/Equipment related:
   a. Use of low and ultralow liquor ratio machines—to reduce consumption of water during pretreatment, dyeing, and post dyeing wash off sequence. Simultaneously reducing the

energy required for water testing at various processing steps and effective load on the effluent treatment (Gardetti, and Torres, 2013).

b. Preheating of process water by solar panels to reduce consumption of others nonrenewable energy sources.

c. Adequate insulation of dyeing, drying, and stenter machines and appropriate heat recovery systems to avoid undesired energy loss.

d. Recycle and reuse of process water and alkali by installing adequate filtration process.

2. Process related:

a. Combined scour and bleach process, combined peroxide neutralizing and biosoftening process, one bath one step dyeing of P/C blends, etc. so as to reduce the number of textile processing stages and thereby reducing consumption of water and energy.

b. Cold pad batch preparation and dyeing for energy conservation.

c. Continuous processing of knits.

d. Pad/dry versus pad/dry/steam, minimizing steam and water consumption during washing processes and minimizing the number of during processes.

e. Foam dyeing, finishing, and coating.

f. Improving right first time and right every time dyeing performance.

3. Chemicals and dyes:

a. Use if enzymes—biodegradable and nondegradable corroding for desizing, scouring, bleach neutralizing, biosoftening, and postdyeing wash off. Suppliers and formulators of enzymes are offering specialized products for combined processes to reduce the number of processing steps (Textile sustainability, 2017).

b. Cationization of cotton for salt-free dyeing with reactive and direct dyes.

c. High fixation reactive dyeing with reduced salt for exhaustion

d. Digital inkjet printing.

e. Low-temperature curing pigment printing.

4. Wastewater Treatment

a. Use of physical, biological, and activated carbon systems

b. Wastewater treatment sludge used/sold for fuel

Atul Ltd., pioneer in manufacturing of dyestuffs in India and a major producer of dyes, pigments, and textile chemicals of international repute is a member of ETAD and supplies products conforming to various global safety and ecological conformance standards like GOTS, REACh, Blue Sign, etc (www.naturalfibres 2009.org, 2009). Atul has already initiated and developed products and processes to reduce carbon footprint not only during manufacturing of dyestuffs but also during the textile processing. Use of renewable energy source based on hydroelectric power of 45 MW, control of gaseous emissions by use of sophisticated containment devices, and a modern ETP and water treatment plant for recycling and reusing of water during dyestuff manufacturing are their key initiatives toward sustainable process approach. Atul has reduced greenhouse gas emission approximately by 15,000 MT/year through innovative technologies and further working on three major projects under the scheme Clean Development Programme (Rupp, 2008). Being the largest manufacturer of vat, sulfur, and reactive dyes in India, they also concentrate on cotton processing and product development, especially in terms of reducing water and energy during coloration and subsequent processes.

4.11 Reuse and recycle value chain of textiles

In terms of reuse and recycle manufacturing of products to Nordic States, the survey emphasizing used textiles in 2014, Poland stood as the largest beneficiary of utilizing the used textiles for around 19,000 tonnes. Lithuania comes second, at around 11,000 tonnes, followed by Bulgaria and Estonia on around 7000 and 6500 tonnes, respectively. Turkey is the only West and Central Asian country in the top 10, with Pakistan, in Eastern Asia, taking the number 10 spot. African countries dot the list, with Malawi, Somalia, Ghana, and Mozambique (Louis, 2012).

In recent years, the product prices are declining significantly with respect to increase in supply of used textiles. Resellers are increasingly working to utilize the whole stock, including lowest quality for reuse and even the plastic bags produced using recycling have improved their margin, particularly in the upper bound value of around $0.05 per kilo (Gwilt and Rissanen, 2010).

4.12 Environmental and social impact of textile supply chain

The research found that the introduction of circular economic principles into the wider value chain of secondhand textiles had a number of beneficial environmental impacts (Ashok, 2015). In 2014, the practice led to an estimated net annual saving of 193,000 tonnes CO_2 and 72 million cubic meters of water use, as well as wider mitigation of environmental impact that comes with the wider value chain of textile production (Rosily, 2016). Benefit to the environment does come with a number of externalities, however, particularly to African textile producers, whose products are undercut by cheaper and often better quality, mostly utilizing the used goods from Europe. However, while textile producers' insight on their operations has been negatively affected, the authors found that the processing of used imported textiles for wider redistribution into the regional populace across Africa created around 9000 jobs directly, 1500 in sorting, 2000 in wholesale, and 5500 in retail, and a further 10,000 in the informal sector, including market sellers and their families (June and 2009Chow Text, 2009).

4.13 Conclusion

Clothing is a vibrant industry that employs hundreds of millions, generates significant revenues, and touches almost everyone, everywhere. Since the 20th century, clothing has increasingly been considered as disposable and as the industry became highly globalized, concepts of designing garment in their one country but manufacturing in another country and selling worldwide is made possible at an ever-increasing pace. This trend has been further accentuated over the past 15 years by rising demand from a growing middle class across the globe with higher disposable income and the emergence of the "fast fashion" phenomenon, leading to a doubling in production

over the same period. The time has come to completely transform the textile system that delivers better economic, societal, and environmental outcomes. Redesigning the fashion's future is the new slogan and the baseline for the circular economy which aims to design out negative impacts and capture the economic opportunity by truly transforming the way clothes are designed, sold, and used.

Efforts are already being employed by brands, retailers, and other organizations to change the industry, and although promising progress is being made, it is often too fragmented or only effective at a small scale. Hence, to achieve a new dimension in the textile and apparel sector, circular economy would demand unprecedented levels of alignment in terms of need for change and collaboration. A system-level change approach is required, including rallying key industry players to set ambitious joint commitments, kick-starting cross-value chain demonstrator projects, and orchestrating complementary initiatives.

References

Adriaanse, A., Bringezu, S., Hammond, A., Moriguchi, Y., Rodenburg, E., Rogich, D., Schütz, H., 1997. Resource flows: the material basis of industrial economies. In: World Resources Institute, Wuppertal Institute, Netherlands Ministry of Housing. Spatial Planning, and Environment, National.

Armstrong, C., Niinimäki, K., Kujala, S., Karell, E., Lang, C., 2015. Sustainable product-service systems for clothing: exploring consumer perceptions of consumption alternatives in Finland. Journal of Cleaner Production 97, 30−39.

Ashok, A., 2015. Carbon Footprints in Textile Processing, 24. PP1-4. fibre2fashion.com.

Bismar, A., 2017. Circular Fashion: Sixteen Principles for a Circular Fashion Industry. https://circularfashion.com/key-principles.

Briceno, T., Stagl, S., 2006. The role of social processes for sustainable consumption. Journal of Cleaner Production 14 (17), 1541−1551.

DeWinter, J., 2014. Circular Business Models: An Opportunity to Generate New Value, Recover Value and Mitigate Risk Associated with Pressure on Raw Material Availability and Price Volatility. Master's Thesis. University of Utrecht, Utrecht, The Netherlands.

Dillinger, P., 2016. Evrnu and Levi Strauss Create First Jeans from Post-consumer Waste. Retrieved from: http://Evrnu.com.

Ellen MacArthur Foundation, 2014. Towards the circular economy. In: Accelerating the Scale-up across Global Supply Chains, vol. 3.

ethicalfashionforum. http://www.ethicalfashionforum.com/the-issues/ethical-fashion.

European Commission, 2017. Initiative Launches to Fight Clothing Waste around Europe. http://ec.europa.eu/environment/europeangreencapital/clothing-waste-initiative.

Gardetti, M.Á., Torres, A.L. (Eds.), 2013. Sustainability in Fashion and Textiles: Values, Design, Production and Consumption. Greenleaf Publishing, Sheffield, UK.

Gwilt, A., Rissanen, T., 2010. Shaping Sustainable Fashion: Changing the Way We Make and Use Clothes. London; Washington, DC.

Institute for Environmental Studies, Japan. WRI Report, Washington.

June 2009. C.K. Chow Textile Asia.

Kering, 2016. Beyond Our Limits. Sustainability Targets 2012−2016. Retrieved from: http://Kering.com.

Lo, C.K.Y., Yeung, A.C.L., Cheng, T.C.E., 2012. The impact of EMS on financial performance in fashion and textiles industries. International Journal of Production Economics 135, 561−567.
Louis, P.F., 2012. Natural News: Beware of Hidden Toxin Sources in New Clothes − Always Wash them Before Wearing.
naturalfibres. www.naturalfibres2009.org/en/iynf/sustainable.html.
Nike, 2013. How Nike Fly-knit Revolutionised the Age-old Craft of Shoemaking. Retrieved from: http://theguardian.com.
Nike, 2016. Top Things to Know about Sustainable Innovation at Nike. Retrieved from: http://news.nike.com/news/sustainable-innovation.
Rosily, 2016. Stella McCartney Talks Sustainability at the Third LCFxKering Talk. Retrieved from: http;//sustainable-fashion.com.
Rupp, J., Nov/Dec 2008. Ecology and economy in textile finishing. Textile World.
Scott, J.T., 2015. The Sustainable Business a Practitioner's Guide to Achieving Long-term Profitability and Competitiveness, second ed. Greenleaf Publishing, Sheffield, UK.
Selly, J.K., 2003. Water Recycling in Textile Wet Processing. Woodhead Publishing, India, UK.
Subramanian SenthilKannan, 2017. Textiles and Clothing Sustainability: Recycled and Upcycled Textiles and Fashion. Springer Publications.
Subramanian SenthilKannan, 2017. Textiles and Clothing Sustainability: Implications in Textiles and Fashion. Springer Publications.
Textile sustainability, 2017. Reuse of clean waste from the textile and apparel industry. In: IOP Conf. Series: Materials Science and Engineering, vol. 254.
Van Ostaeyen, J., Van Horenbeek, A., Pintelon, L., Duflou, J.R., 2013. A refined typology of product−service systems based on functional hierarchy modeling,. Journal of Cleaner Production 51, 261−276.
Wang, Y., 2006. Recycling in Textiles. Woodhead Publishing, India, UK.

Further reading

Rissanen, T., 2014. The Fashion System through a Lens of Zero Waste Fashion Design. Rissanen, T. McQuillan, H. (2016). Zero Waste Fashion Design, Bloomsbury.

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Upcycled and low-cost sustainable business for value-added textiles and fashion

5

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5.1 Introduction

The United Nations World Commission on Environment and Development (1987) terms sustainability as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Resource depletion, climate change, and unequal, skewed development relative to the global population are some problems confronting the world. Europe has been a model to the rest of the world regarding practice and legislation toward limiting climate change (Nilsson and Varnäs, 2009). The European Economic and Social Committee, an advisory body of the EU at a meeting held in Madrid in 2014 on "Best practices in the domain of built-in obsolescence and collaborative consumption," suggested that sustainable consumption be declared a consumer right in EU legislation. This would restrict the trend toward fast fashion and overconsumption (EESC, 2013; Staniškis, 2012).

It is essential to understand the sources of textile waste for the success of textile recycling and textile waste management and minimization strategies. Textile waste is conventionally classified into postconsumer waste, preconsumer waste, and production waste based on their sources (Teli et al., 2014; Farrer, 2011). Postconsumer textile waste results when a garment comes to the end of its first use life cycle. It mainly consists of used garments and domestic textiles. In developing countries like Mexico and Poland, 98% of textile wastes end up being sent to a landfill. The proportion of the textile wastes composed of natural fibers is just one-third, while the remaining is made of synthetics. Preconsumer waste is due to excess production of clothing; a new type of waste has emerged that includes leftovers from store sales and company product development trials, faulty returned goods, and outsourced garment shipments that were not redeemed from customs for any reason. Production waste from the industry contains fiber, yarn, and fabric remnants from garment factories, such as decorative clippings, patterns, excess remaining fabric, cut-offs, roll ends, etc.

Cheap fashion is in high demand causing the fast fashion clothing market to expand appreciably in response to the consumer. Such purchase of "use and throw" wearable clothing goods is favored by the relatively low prices while also driving

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00005-4

the quality downward. These factors promote an exponential increase in textile waste while decreasing available textile supply in future. The glut of clothes output of poor quality by textile manufacturing needs to be curtailed and redirected to better utilization of ecological resources (Morgan and Birtwistle, 2009). Modern capitalistic society has bought the latest in all consumer products without sufficient thought as to the impact of our purchased goods on the environment. Consumers have purchased more goods than needed because of cheaper prices, so industries of all types have reacted by producing cheap, badly tailored, resource-intensive goods. Effect of fast fashion on growing waste has been to increase the textile waste per individual. Most Americans throw away 70 pounds of clothing and textiles every year, but almost 95% of that could be recovered by recycling. The export of used clothing had tripled in volume at the end of the period 1989–2003 to 7 billion pounds largely due to the make-use-throw fashion trend. Another reason for increased waste is increased purchase rates. Every year worldwide, consumers have purchased one billion garments made in China, which was equivalent to four pieces of garment worn by every American citizen. There has been an increase in the proportion of clothing discarded in the solid waste stream. In 2010, 8% of the solid waste collected in the United States was old clothing, leather, rubber, and other woven fabric. In the United Kingdom, textile waste was only 7% of the solid waste stream, but 5 years on, it had increased to 30%. There has been a significant increase in textile waste in the US fashion industry as most manufacturers throw cutoffs, surplus, or incorrect material, etc. The recycling rates for textiles have not increased, and only 15% of all textiles disposed of in the United States have recycled annually. With rising expenditure and lower prices, consumers have unfailingly wanted wider variety for their fashion while paying much less. In the sale of used clothing, there have been secondhand stores which have many names, branded labels for one-fourth of the cost of regular retail prices.

Nowadays, “built-in obsolescence” is a feature of products designed to last for a short period. The reason for this is to promote and encourage the customer to discard it at the earliest and buy another replacement. This is typical of the fashion industry. Customers are unaware that once the product is discarded, it is only the tip of the iceberg of a large pile of waste material. The product itself only contains 5% of the total raw materials involved in the process of manufacturing and packaging it. Economic growth is the terminal goal of modern industrial operations which occur, at the expense of the planet’s health. The destruction is real and extreme.

According to the William McDonough and Michael Braungart (McDonough and Braungart, 2002, 2010) all manner of waste end up in landfills. Although some can be decomposed in the landfill, it is possible that others may be recycled and some could even be upcycled. Currently, products are often designed with “built-in obsolescence” so that they only last for a short duration of use. A classic case of obsolescence, due to lack of innovation, are nylon stockings. The inevitable “laddering” of stockings make consumers buy more pairs, which for decades has discouraged manufacturers from searching for a fiber that did not ladder, when a higher denier, microfiber replacement was possible. Fashion is deeply committed to built-in obsolescence, even though there has been a stylistic revival of ‘vintage’ clothing, at the luxury end. It is time that manufacturers and designers realize that this strategy can no longer be supported,

but they need to generate alternate solutions (McDonough and Braungart, 2010). Such solutions often involve finding out several ways to use old and waste materials, positioning them at the juncture of sustainability and profitability. One of the most economical and fashionable alternatives is to "upcycle." Upcycling is the process of transforming waste materials or useless products into new materials or products of better quality by adding valuable features and remodeling. Upcycling is required to replace the need for producing new things to fulfill the heightening consumer demand.

If the demand does not decelerate, it has to be satisfied, and new production will only encourage the vile cycle of overconsumption and its attendant problems, while also reducing the source material reservoir; so the demand has to be met in an alternate way such as using already existing recycled materials to make new products. The textile industry is an example of such difficulties and the solution of economic upcycling is becoming popular among those interested in mitigating climate change. Upcycling, the next level of recycling, requires energy and resources to collect, arrange, and process the waste to make something valuable out of used material. Hence, upcycling is even more ecologically sound than recycling. When utilizing already existing waste materials, the consumption of fresh raw materials for producing new goods decrease, which could result in a reduction of energy usage, water and material use, environmental pollution, etc. Upcycled products are a means for the vendor to do business and for the consumer to continue purchasing, while the goals of business remain unchanged, all the while keeping the concerns of environmentally fair resource usage in focus (Teli et al., 2014; Farrer, 2011).

Textile industries' growth and profit rise and fall, influenced by factors in their own country and those related to the worldwide economy, as demonstrated in the current globalized fashion market. An increase in demand and decrease in supply is a concurrent problem for the textile industry, independently on where it is positioned. When manufacturers choose to implement a strategy of change from the current impasse, they practice processes of recycling, bringing them closer toward the concept of *cradle* to *cradle.* A critical step in the *cradle-to-cradle* practice is recycling wherein closed-loop cycle ideates from the theoretical possibility of producing a newer generation of products from limited resources.

The circular economy is a model which aims to keep products, components, and materials in circulation as long as possible and retain their value in the circulation. In a circular economy, the products have been primarily designed to circle as shown in Fig. 5.1 (Recycler, 2016). Recycling is the reuse, remodeling, revamping, or reprocessing of a material or product with the goal of minimizing waste. A huge amount of textiles end up in landfills every year and recycling is one of the most efficacious methods to resolve this issue. Upcycling refers to the reuse of textiles where its quality is maintained or increased by the procedure, reconciling a common disadvantage of recycling practices, degrading the quality of the original materials, as occurs when the worn out material is recycled. By upcycling textiles, garments can be offered an extended life and prevented from terminating in a landfill (Claudio, 2007; Gwilt, 2011; De Brito et al., 2008; Caine, 2010).

Similarly, value chain analysis and recycling strategies in the field of textile and fashion sector is not a new, but an old concept that has gained focus recently. The sector

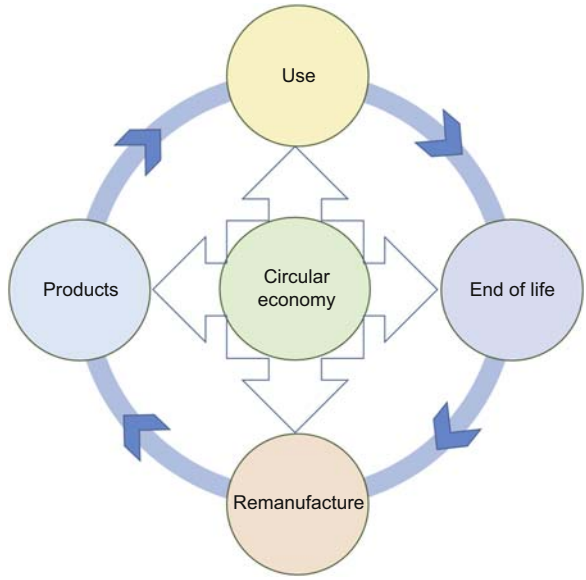

Figure 5.1 Circular economy.
Imitating: The Recycler, May 2016. Circular Economy Knowledge "High" in US Business. http://www.therecycler.com/posts/tag/circular-economy/.

unifies two main branches, the distinction between the two product areas "textile," which includes every kind of product made of textile fibers, and "fashion," which refers to the area of activity that involves styles of clothing and appearance. However, textile and fashion together contribute a good business dynamic. Indeed, production and market dynamics related to the individual textile and fashion segment could be very different. There are many fashion designing professionals as well as textile engineers who have worked in this avenue successfully, yet many solutions remain to be investigated.

In the present chapter, first, a status view of the available market for recycled textiles is attempted, next different available business strategies for the textile market incorporating sustainability and modification of consumer choices are discussed, followed by a review of case studies involving particular features of consumer habits regarding recycled textiles and industry efforts to convert to upcyling textile products. Finally, the barriers to overcome and solutions to achieve positive gains for the environment and the economy in relation to textile recycling and fashion redefinition are discussed.

5.2 Market for recycled textiles

The textile reuse and recycling industry consists of distinct players like textile manufacturers, retailers, consumers, collectors and processors, and end markets. To achieve the recovery of textiles, collectors may operate in different formats—for profit units,

nonprofit or charitable units, and hybrid models. Brands need to represent the demand for these recycled fabrics and actively encourage a sourcing culture and buying standard that supports recycled content—slowly reducing virgin content while the industry moves from a linear to a circular model. The more consumers and marketers demand recycled material, the more widely available and affordable these fabrics will become. A circular textiles industry is dependent on used resources being fed back into the system. Closing the loop, therefore, means that brands take the responsibility to act in mass balance, collecting and recycling as much as they produce, keeping textile resources in circulation (Lewis et al., 2017; Closing the Loop, 2015). The ideal to work toward is to "close the loop" for textiles and create a system whereby products, fabrics, and fibers are infinitely and effectively cycled through connected loops within and across industries in a transparent and economical way. Such a system will capture the inherent value of textiles while eliminating waste downstream and displacing the virgin industry upstream. In order to close the loop, conventional recyclers must combine and develop technologies to generate suitable feedstock for new textile production. Real circularity in the clothing industry can only be achieved if textiles can be recycled once they have reached the end of their useful life and can find their way back into new products. Factors causing the textile waste problem are high textile consumption, the absence of recycling awareness, and deficient operations and systems to handle and organize textile recycling. Advanced countries like the United States and the United Kingdom carry on consuming high volumes of textile products, driven by the push of the fast fashion industry.

There is a long human cultural history of textiles being reused and recycled. Traditional recyclers gather, classify, and redistribute waste textiles as part of a global market, and new recycling technologies convert old clothes into new fabrics. Collection procedures range from donation centers, thrift/consignment stores, donation boxes, curbside programs, and retail stores to charity from fundraising events. Collected textiles are then classified into separate grades and types of materials from reusable, resalable merchandise or recyclable to nonusable stock. Used clothing comes in two categories—wearable and mutilated. It is only through sorting that we can ensure that a used textile item can maintain its maximum environmental and economic value and be recovered in the most efficient manner. Almost half (45%) of collected textiles are sold and reused as secondhand wearable clothing, 30% of materials are converted into wiping and polishing cloths, and 20% are shredded into fiber materials according to SMART (SMART, Association, 1932). The remaining 5% is unusable and is disposed of charities and thrift stores and consignment stores obtain sale stock from the usable goods which are donated or bought at low rates. The unusable goods are eventually sent to rag sorters and processing facilities to further recycle these materials.

There are a number of recycling end markets, many of which are "open-loop" recycling process units in which the fiber is used in a recycling process in place of another material. Some examples are replacement fiber in insulation, automotive felt, wipers (used in industry to soak up spillages), flocking (shredded textiles used as filling in mattresses and seats), rags exported to cheap labor–employing countries for the production of blankets and rugs), and fiber-to-fiber recycling. Some recycled

supplies are also employed for horticultural padding and equestrian felts. Some end markets experience poor demand like in the wipers market, which forecasts low growth, as the customers mainly in manufacturing sectors do not foresee increased sale, with competition from substitutes (e.g., paper-based wipes).

In 2018, the clothing market is likely to be crowded and difficult to trade in several countries, such as East Africa and China, which are trying to ban used clothing imports because governments assert that this will help to support increased clothing/textile production in their own countries (despite contributing further to the local environmental problems associated with the industry). Government decision-makers in East African countries imply that the import of secondhand clothing into the region hurt their local textile manufacturing industry. This contradicts the existence of countries like Pakistan, Guatemala, and Honduras, which host both robust manufacturing and secondhand industries. Most of the textiles manufactured in Africa are exported for sale in developed countries, including the United States and the United Kingdom, rather than being sold locally where they were created. According to the Overseas Development Institute, an independent research unit focusing on international development and humanitarian issues, halting secondhand clothing trade would not enable development of local textile industry but have the undesirable effect of promoting illegal trade and smuggling in banned imports, when the local population is forced to choose between buying new imported garments or buying domestically produced low-grade goods (Textiles Market Situation Report, 2016).

The main factor set to change markets permanently is the emergence of China. Until 2010, it exported virtually no used clothing, but by 2015, it had become the world's fifth largest exporter. However, China has decided on banning imports of textile scraps in order to control its own pollution, but the Institute of Scrap Recycling Industries (ISRI), an advocate of global textile recycling, is opposed to measures that restrict the free flow of commodities, including material scraps, worldwide, and has taken it up with the World Trade Organization. The organization suggested that China needed to clarify its classification of what is termed waste or scraps and make clearer regulations for the exporting community, so they are aware of which products are allowed for import. ISRI considered that it was in the interests of the US recycling industry to support China in reducing pollution and helping it develop better domestic collection practices moving forward. Values of used clothing in the United Kingdom rose gradually across all grades in the first half of 2017. This was a continuation of a trend that started after the on remaining or leaving the European Union and the subsequent fall in the value of the pound, which meant that British used clothing became a bit cheaper and a bit more affordable for customers in Africa, Eastern Europe, and elsewhere.

The major issue in the used clothing business is that it, by nature, being big volume, low margin, unregulated, and opaque, middlemen make millions of dollars for their own organizations or social projects, but there is little impact on the really poor of the third world, while at the same time transferring the final accountability of millions of clothes first used in the developed world, worn and torn by the poor in the third world, going into third world landfills, far from the affluent first world. The beneficiaries of the used cloth trade are the exporters in the United States and United Kingdom, and the wholesalers, as well as their counterparts in the importing countries.

The actual consumer in the developing countries can also purchase good quality clothes for a fraction of their original price.

Recycling markets must function effectively to make it economically attractive. The barriers and failures faced by recycling markets need to be understood and overcome, while governments need to facilitate continued growth in the use of recycled clothing, by policy measures such as public collection schemes or product standards, imposing a minimum level of recycled content. Policy measures meet limited success when the cost of meeting the targets are determined by an inefficient marketplace subject to price volatility, propagating uncertainty, discouraging investment, and undermining the financial viability of recycling. Dumping in landfills would be more economical than taking to the market, in the worst scenario. Market weakness is driven by the search and transaction costs (such as storage of huge cloth waste), information failures, consumer perception and risk aversion, as well as technological hurdles. Recyclers may incur significant search costs in identifying suppliers of recyclable cloth, while the quality of clothing material needs to be sorted and graded, before agreeing on a fair price, hence the transaction cost. Public authorities could reduce transaction costs by having market surveys for buyers and sellers, to contact each other, along with prices and trends in materials, along with grading and certification schemes (Comley, 2007; Ellen MacArthur Foundation, 2017; OECD Observer Policy Brief, 2007).

Loop works—an online apparel start-up was taking steps to reverse that wasteful trend. Using no new materials, everything in the Loop works line was uniquely created from excess. Loop works offered fresh, numbered, limited-edition, eco-friendly clothing (Zamani, 2014; Klepp et al., 2014).

5.3 Sustainable business strategies

The circular economy, a concept originating from environmental economics, general systems theory, and industrial ecology, is used to address the sustainability challenges. The rapid advances in technology can be used to help solutions that build a circular economy. Initiatives were taken to utilize the textile waste products on the basis of sustainable strategies through the method of upcycling or recycling for the thrown away textile and attempt an approach to shift from a linear flow model to a circular one. The concept of sustainable development of the business is described and needed for coherence between three bottom lines (TBLs) of measuring success on business—financial, social, and environmental parameters is stressed as shown in Fig. 5.2(a). Previously business success used to be measured solely in terms of gross profits on the balance sheet the company declared to its shareholders. In fact, "generating profit" was considered the only aim of business and thus, many business practices could be faulted for deficits in corporate social responsibility/commitment or environmental protection. Over time, business success has been based on the measurement of TBLs: financial, social, and environmental, where a prosperous business organization is expected to do well. This corresponds to the factors, profit, people, and planet, which a sustainable fashion system has to involve for a successful business strategy as shown in Fig. 5.3

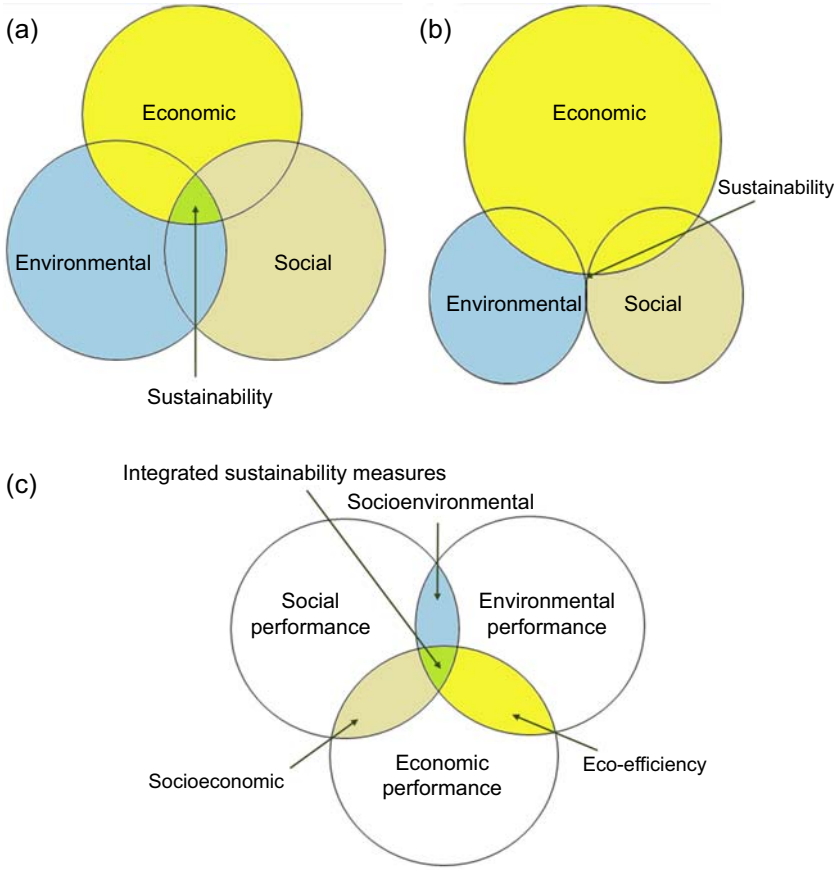

Figure 5.2 (a) Sustainability model, (b) Greenwash, and (c) sustainability measurement scheme (Khan, 1995; WCED, 1987).

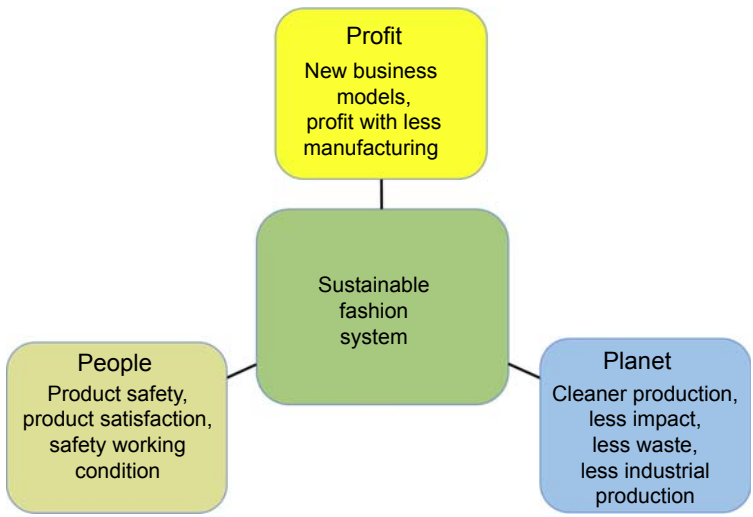

Figure 5.3 Sustainable fashion system (Niinimäki, 2015).

(Niinimäki, 2014, 2015). Often profit-focused companies consider social compliance and environmental compliance more as a handicap such as when following the legislative norms and complying with the laws, they commit cosmetic imaging, also called green-wash represented in Fig. 5.2(b). In reality, the integrated sustainability as shown in Fig. 5.2(c) remains difficult to achieve.

5.3.1 Sustainable business strategies for textile and fashion industry

Strategies for upcycling of damaged textiles goods could be carried out through various ways such as dyeing, e.g., reactive, vat, sulfur, direct dyeing (for white and light goods); printing, e.g., tie and dye, batik, transfer, novel printing, etc.; finishing process, e.g., softener, resin; stitching of goods (sticker, bag, belt, etc.); fashion technology, e.g., ramp walk, fashion show; stain removal treatment, e.g., by washing with peroxide solution or an organic solvent.

Re-education of consumer habits and practices in the following ways can also promote the upcycling industry—choosing to buy upcycled home decor, appliances, fashion, and much more through thrift stores and consignment shops; recycling used fashion when one no longer wants to use old clothing and jewelry; by donating to a local charity or a textile collector; choosing high-quality consumer goods so that eco-shopping helps economize and reduce the total resources consumed; upcycling by reusing items at home from containers to cardboard boxes to paper gives a life extension; taking care of fashion, making fashion last longer by reducing wear and tear, for example, by washing less frequently (if unstained and unscented) and at low-temperature setting on the wash cycle; leasing fashion for specific and important functions when the fabric is worn only once (leasing or renting something rather than buying new makes more economic and ecological sense). Repairing before recycling, when searching for means to extend the life of fashion or other consumer goods like small appliances, is always ecologically sound.

5.3.2 Strategies for sustainable business by brand positioning

Brand positioning of sustainable textile products is essential both to attract consumers and to make the recycled and upcycled products gain and grow their own market. Hadhi, a brand, offers a selection of functional products also useful for pure decoration or as innovative gifts, from tables made out of old magazines to lamps. Approximately 40% of Hadhi's product range consists of upcycled textile material because of the fair trade conformity of products. Hanne Beutel's brand offers handbags and purses made from upcycled materials like old leather used jackets or pants and waste wool or cotton from old furniture. Every bag is handmade with a unique design that evokes joy, femininity, and elegance. Functionality and sustainability along with exclusivity in design and ecological awareness were central to the brand (Torstensson, 2011).

Rewind Design contains a combination of environmental concern and esthetics. The company built a concept around eco-design with recycling and upcycling.

They make a wide variety of products, like Fatboy bags made from reused materials and bags using old tires with the label of Rewind Designs. The company's philosophy was based on a quote by Albert Einstein—"The world will not move beyond its current state using the same thinking that got us there in the first place." Approximately 15% of Rewind Design's product offering contains upcycled textile material. The upcycled textile products by Rewind Design were priced at the high end such that their typical customers were those of high income attracted to the responsible luxury image and creative design.

5.3.3 Service life of garment

The stream for used clothing category arises from use, wear and tear, and other fallout. Mutilated garments that are damaged irreversibly cannot be upcycled, although those with fewer defects could be taken for upcycling. The specific factors that decrease the service life of a garment are heavily affected by its end use (Saville, 1999). Changes in a fashion prevent the garment from being worn due to stylistic obsolescence even if there are no defects. Shrinkage or dimensional changes such as uneven stretching may make the garment unsuitable. Modification in surface appearance due to pilling, surface fuzz formation, fraying and thinning threads, friction rubbing causing shiny areas to form are some ways that may reduce the acceptance of garment to be worn. Color fading of the garment may happen due to extreme washing or light exposure. Color bleeding from one area to another may distort printed designs. Seams of the garment may give out due to seam slippage or breakup of the sewn stitches. The fabric may wear out into holes or the surface finish or pile may wear out threadbare, reducing garment function. Cuff edges, collars, and folded-over edges may wear out to give a frayed appearance, contributing to discard of the garment. The fabric may tear if snagged by a sharp object and may mutilate the clothing.

5.3.4 Consumer choices for ways to discard used clothing and household textiles

The use of landfills may be reduced by avoiding the discard of any textiles since even a rag may have some recoverable use and value. Textiles, including biodegradable natural fibers, do not easily degrade within landfills in the absence of sunlight and oxygen. Garage sales could provide an outlet to sell used clothing. Resale shops can act as a good market for unique used pieces by providing a route for used material by allowing consumers to buy an item outright or by offering an installment scheme. Charities are an excellent option for clothing donations and it may be promoted by tax deductions. However, one needs to avoid flooding charities with excess donations of textiles and clothing in times of disasters by making a habit of regular donations during normal times. When faced with providing help during disasters, large amounts of donated goods may not be handled appropriately by the organizations confronting time limits, transportation problems, and paucity of labor required to arrange, clean, and redistribute donated goods. So limiting donations to routine rather than

encouraged by disasters is a good model. Donated clothing needs to be moisture free to prevent fungal damage. Before composting, components of clothing like zippers, buttons, etc. have to be stripped off, and it may be preferable to donate such items. Composting is favored for discarded textiles composed of natural fibers (cotton, linen, wool, and, silk). All the options for routes to disposal considered so far can control air pollution, avoid incineration, and work as good sustainable pathways for business (Wai Yee et al., 2016; Bianchi and Birtwistle, 2010).

5.4 Case studies

Some case studies of specific features of textile recycling and existing scenarios in different world regions of the textile market are considered here with regard to the following:

- Garment upcycling to achieve a sustainable business model.
- Fast fashion realignment, ecological rebranding, and correction in Europe.
- Industries actively pursuing recycling of textiles to generate products with profit and popularity.
- Redesigning fashion from the perspective of future recycling of the product, extending its service life.
- Existing local textile recycling and upcycling (industry-merchant-vendor-consumer) circles in multiple geographic locations.
- Consumer tendencies and consumer re-education with regard to upcycled textile products.
- Refurbishment of the waste textiles by upcycling it through different chemical treatments with cheaply available waste chemical resources, adding value and function.

5.4.1 Upcycling of garments for sustainable business

The used old garments were procured from the neighborhood markets of Mumbai, India, and based on their quality, state, and appearance, there were different rates on the price of the garment. The buyers were mostly acting as middlemen in purchasing the garments at a lower market rate and selling them to another merchant, who could process the garment with respect to refurbishing and resale. The collected garments were sorted based on the condition of the clothes, fiber composition (whether synthetic or natural fiber, microfiber or knit), color (pale or dark), whether worn by male or female, size range and target age group (junior, youth, or adult), etc. After the segregation, garments were washed with detergent to clean out adhering dust, dirt, and soil. Renovation of the garments was carried out by physical and chemical treatments. The physical modification involved cutting and retailoring of garments or clothes, while chemical treatments like soaping, bleaching, dyeing, printing, and finishing could be applied to the clothes.

After the garment was treated as necessary for upcycling, they were evaluated for improvement in wear performance such as pleasing appearance and attractiveness as also in terms of efficiency and effectiveness of the renovation process. In sum,

65 people, approximately 60% female and 40% male spread across different age groups between 20 and 40 years, participated in the assessment. After a detailed examination, the assessors gave ratings to the different products along with the estimated approximate cost, at which they would prefer to buy. The ratings, given in a range of 1−10 wherein 1 is poor (10% improvement) while 10 is excellent (100% improvement) were awarded and estimated price was assigned based on the perception of the participating individual. The average value quoted by 65 different people, the mean value of the product rating given, as well as the estimated price was used in developing the profitability analysis. Cost analysis was carried out to determine the percentage profitability of the upcycled products as shown in Table 5.1. As shown in Eq. (5.1), it involved the complete cost of upcycled goods, including purchase cost, water used, power expended, dyes and chemical used, labor price, along with miscellaneous expense. It was observed that all prices quoted by the putative buyers were lower when they were aware that the products were upcycled, indicating the psychological influence of preconceptions on their purchase price.

$$\text{Profotability}\ (\%) = \frac{(\text{Upcycled good selling price}) - (\text{Total cost involved to upcycled good})}{\text{Total cost involved to upcycled good}} \times 100 \tag{5.1}$$

Table 5.1 Summary of 10 samples in terms of their processes, ratings, and profitability (Teli et al., 2014)

Sample number	Product	Processes carried out to upcycle	[a]Rating (1−10)	Profitability as upcycled product (%)	Profitability as new product (%)
1	White jacket	Dyeing	7.41	68.93	142.89
2	Baby frock	Dyeing	7.02	63.60	146.76
3	Baby top	Dyeing	7.55	93.30	133.29
4	Printed shirt	Dyeing	6.84	90.80	191.47
5	Violet top	Print	6.83	250.39	409.64
6	White frock	Print	6.72	501.00	766.09
7	Torn jeans	Stitch	6.83	106.35	199.09
8	Torn jeans	Stitch	6.73	181.94	344.76
9	Violet T-Shirt	Enzyme wash	6.56	156.44	250.01
10	Black top	Dyeing + Print + Stitch	6.44	257.88	444.24

[a]Note: The rating of product contains value 1 to 10 in which 1 was poorest while 10 was excellent.

In sample 1 a jacket was contaminated by the presence of rust and blackish spots which could not be removed during soaping. Hence sample 1 was treated with the reactive orange at 2% shade to cover the black spots and give a renewed, colored appearance to the garment. From Table 5.1, it was found that this product rating, assigned by the sample consumer, was 7.41 and the profitability (%) as upcycled product and as a new product were approximately 68.93% and 142.89%, respectively. Similarly, sample 2 was originally yellow in color, but stained, and it was upcycled using Coracion G. Yellow HER with 1.5% shade to enhance the esthetic value. The dyeing of the baby top (Sample 3) was carried out with reactive dye. The uneven fading of the top was covered by uniform dyeing. The dyeing on printed shirt (Sample 4) sized for small boys was treated using Reactive Red with 5RB 0.5% shade to improve its appearance value. The original top had a duller appearance (Sample 5) and hence it was treated with gold printing to catch the buyer's eyes by a print-dry-cure process. The original white top (frock) (sample 6) was subjected to printing with red pigment using 1% imperon Red in printofix 200 by a print-dry-cure process, which gave a different look as compared with the traditional one. Jeans samples were torn (sample 7 and 8) such that they could not further be used, and hence they were cut and restitched to make a strong carry bag with side pockets on both sides, with longer length size, mobile cover, and other accessories, etc (refer Fig. 5.4). Huge amount of pills appeared on the T-shirt surface (sample 9) and it was subjected to an enzyme wash using 1.5% owf (on weight of fabric) KEM 240. The original lady top

Figure 5.4 Picture showing the image of (a) received sample and (b–d) upcycled sample of denim jeans fabric.

(sample 10) showed a faded effect and dull appearance. In order to overcome the problem, it was subjected to dyeing with a dark black color (direct dye) using Solar black with 2% shade to give a newer appearance. After survey (Table 5.1) it was found that most of the upcycled textiles samples' product rating and estimated profitability percent was good. Also, if it can be considered as a fresh sample, it would have fetched a good profitability percent.

Thus profitability estimated on purchase price is assured. The upcycled goods have a wide possibility of being sold in tier 2 and tier 3 cities and towns where the purchase price will be higher, as the customer gets access to recent fashion at lower cost, and in that case, the initial profitability will be increased many fold. Upcycling is not just an environmentally favorable and sustainable process, but it can also open up another front for an entrepreneur to gain high profitability and build a genuine business construct. The present textile business, even the most modern composite mill, cannot make more than 20% profit. In this backdrop, the profitability of upcycling business will surely be an eco-friendly operation and ecologically sound proposal (Teli et al., 2014).

The main purpose of an India-based study (Patel and Pandey, 2015) was to prepare different articles from waste textile materials According to the needs the articles were designed, which includes denim trousers for construction of a bag and a miniskirt, whereas old discarded socks and sarees of different colors were utilized to make a foot mat and basket, old tie dress, and old shirt used to construct the skirt. Denim trousers were used to construct the bag and denim miniskirt. The skirt was stitched employing sewing machine as shown in Fig. 5.5(a). Old ties of various colors were stitched side by side to make a one-piece garment as shown in Fig. 5.5(b).

In the same case study observations regarding the barriers in marketing and distribution were assigned by the respondents to factors such as lack of market, cost of production, lack of technology, and lack of equipment as shown in Fig. 5.6. Among them, lack of market is the major key factor, whereas lack of equipment is the least significant (Patel and Pandey, 2015).

5.4.2 Europe—challenges used for clothes management

Europe and the world were facing problematic issues related to resource depletion, climate change, and a global economic crisis. Europe has taken leadership in developing guidance to the remaining countries concerning climate change mitigation solutions (Nilsson and Varnäs, 2009). In Europe, consumers buy more clothes and other textile per capita compared with the rest of the world. Many brands which previously offered seasonal commodity have changed to showcasing new items every day. The demand for cheap fashion increased, and the fast fashion clothing market had expanded in response to satisfy consumers. Today's fast fashion product suffers greater wear and tear, poor and run-of-the-mill garment detailing, where the low purchases prices influence poor end product quality; the customer's expectations being that the garment is not made to last. These conditions increase textile waste while reducing future textile supply. The EU textile industry generates waste estimated at 16 million tons per year. Handling of much of this waste through landfills or

Figure 5.5 Upcycling of old textile materials such as (a) denim skirt and (b) tie dress (Patel and Pandey, 2015).

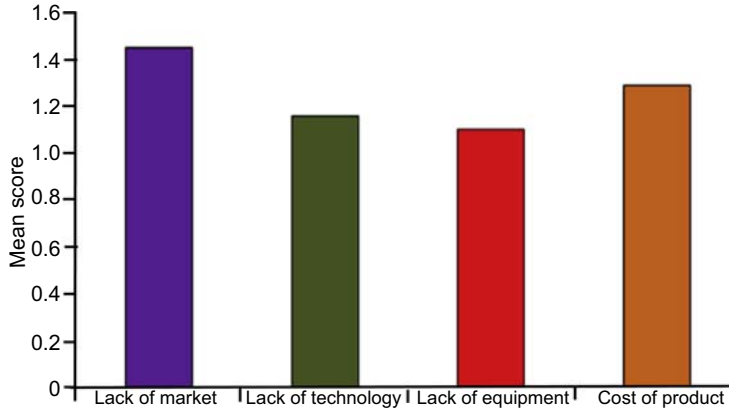

Figure 5.6 Weightage of barriers in marketing (Patel and Pandey, 2015).

incineration comes with a high environmental and economic cost. Loss of valuable resources locked within the waste occurs. It is the industry and consumer's obligation to get the wasteful glut under control, if not eliminate it (Morgan and Birtwistle, 2009).

An example of such an initiative to tackle the growing clothing and textiles waste issue across Europe is one program launched by the UK-based organization http://www.wrap.org.uk/ (Waste & Resources Action Programme)—the European Clothing Action Plan, which has the goal of diverting over 90,000 tonnes of textiles away from landfills by 2019. Eleven countries, Denmark, Finland, Germany, Italy, Netherlands, Norway, Poland, Romania, Spain, and Sweden including the United Kingdom, have agreed to participate, which WRAP also hopes to extend to Asia in future. It aims to improve the sustainability of textiles across their life cycle from design to end of use, through a circular economy and resource-efficient approach. It brings together industry, government, and retailers, besides campaigning to change consumer behavior. The UK-only scheme, Sustainable Clothing Action Plan (SCAP), 2020, has 80 organizations, representing 45% of the United Kingdom's retail sales,

such as New Look, Next, Sainsbury's, Debenhams and Tesco, as well as top British designer Stella McCartney, signed up with a commitment to reduce the waste, water, and carbon footprints of clothing supplied or received in the United Kingdom, based on 2012 levels. SCAP also seeks to improve separation systems, prioritizing reuse over recycling, as reuse is the more eco-friendly, energy-efficient, and cost-effective option. If the SCAP 2020 targets are met, this would achieve savings of 16,000 tonnes of waste, 420 million m^3 of water, and 1.2 million tonnes of CO_2 emissions (Europa).

The Horizon 2020 Societal Challenge 'Climate action, environment, resource efficiency & raw materials' for Europe sponsors RESYNTEX, a textile recycling plant as an innovative pilot project that could recycle 500 tons of waste per year. It would transform textile waste into secondary raw materials, creating circularity and reducing environmental impact. The waste utilized by the process is residual textile waste (clothing and household textiles, uniforms, and mattresses) which may not be taken for profitable reuse. The complex waste streams from furniture, end-of-life vehicles, textile manufacturing, and carpets were not favorable for recycling due to inaccessibility (without modifying current collection/sorting procedures); competition (commercially available recycling options already exist); and economies of scale (only low-to-medium concentrations of textiles are found in the waste).

The sorted, unwearable textile waste is chemically treated to extract feedstocks for the chemical industry such as protein-based fibers to be used for producing wood panel adhesives, and cellulosic fibers for the production of bioethanol. Polyamide and polyester recovery is also carried out to produce new chemicals and plastic bottles, from their monomers and oligomers (Bell et al.).

5.4.3 Industries' approach toward upcycling

Upcycling is now taking wing in most countries, influenced by the increased interest in eco-friendly products, especially those priced affordably while also providing profit to the manufacturers. If upcycling is to prevail as the norm, then business needs to see it being actually profitable. British company *Elvis & Kresse* Organization used industrial waste to manufacture original luxury products, converting fire hoses into accessory wear like bags, belts, wallets, and cufflinks. Companies like Nike, Adidas, and Royal Robbins, are involved in upcycling, which means the upcycled clothing might actually be attractive enough to wear. Tetracycle was the first company to manufacture upcycled goods (Patel and Pandey, 2015). Upcycling is leading an entirely new surge of entrepreneurial transformation. The popularity of upcycled goods is visible in the offerings of online market places like Etsy and ArtFire.

In the last 20 years, the trend of fast fashion consumption has caused a twofold increase in textile waste; today the average American disposes of around 70 pounds of textiles per year, most terminating in landfills. The consumer demand for textiles by region is as follows—North Americans, the heaviest users at 37 kg each, Australia at 27 kg, Western Europe including the United Kingdom at 22 kg, followed by the developing nations such as Africa, India, and southern Asia at only 5 kg per capita. This is significant to consider since discard waste relates to initial consumption. Table 5.2 exemplified companies showing the conventional manufacturers, solutions

Table 5.2 Companies: The material upcycled and it's benefit (Macomber et al., 2011; Fashion; Wang, 2011)

Company	What material is upcycled?	Advantageous output
Hammer and Hand	Home construction and reusing materials for furniture	Retaining jobs, while generating a new revenue stream
Hello Rewind	Customers' favorite old T-shirts were converted into laptop sleeves	A self-sustaining social enterprise that showcases a sentimental, one-of-a-kind product, while profits help sex-trafficking victims
Hermès	Leftover material and damaged goods remade into a new line of accessories and décor	Proving luxury could be sustainable and high priced
Loop works	Overproduced textile waste regenerated into a new retail line	Factory waste could be used rescuing raw materials (for a profitable price)
Patagonia	Fleece made from plastic bottles	Promoting a clean manufacturing movement among outdoor-wear manufacturers
Terra Cycle	Trash to make new retail products	Trash modified into valuables
Evrnu	Cotton garment waste upcycled into newer, stronger fiber	Reduces textile waste and creates a new resource for designers and fashion brands.
ReUse Jeans	Preconsumer waste from denim factories of defect and leftover fabric is shredded, spun, and woven anew	Jeans made from 80% recycled material, reduced environmental impact

to rethink product design and resource use, such as refurbishing apparel to upcycling it, to recycling garment waste into the renewable fiber that otherwise would end up as landfill waste (Carmichael, 2015; Brones, 2016).

5.4.4 Fast-changing fashion

The fast-changing fashion trend is responsible for climate change as the buyer procured cheaper garments and used it for a minimum period of time and discarded it as waste which moves into landfills. Deforestation, water pollution, and solid waste generation increased due to overconsumption of clothing in the fashion industry. The waste per person increased tremendously due to lower purchase rate, disposal, or landfilling, which also increased the greenhouse gas emissions in the environment.

Many researchers are working on old garment reuse either by upcycling or recycling in order to improve the service life of the garment. Some cases are listed in the following sections.

Farrer (2011) explained the fast-changing fashion impact on the environment along with a solution in the form of upcycling. The upcycled textile goods were offered to the consumers in a practical way by the big market players. The life cycle of a garment based on the environmental impact assessment during its manufacturing to end life was analyzed. A model was constructed for fashion design upcycling by various techniques of designing. The conclusion reached was that textile material could be used as source material for upcycling textile waste and it could be classified into postconsumer waste, preconsumer waste, and production waste, all of which could be utilized in fashion design. Based on the input material, it needed different techniques, also influenced by the purpose of the designed product and its functionality. Postconsumer waste turned out to be suitable and easy to use for producing one-off designs and for making theatre costumes (Farrer, 2011).

Tipton (2013) reported a new method called "tattering" to convert used clothing into wearable clothing. The process was recorded and modeled as stepwise instructions. Three women's dresses were formed into a man's garment by using a tattering method and the difference in design of men's and women's was compared. The study showed that recycling used garments maintained and increased the value of garments, extending their life instead of ending in a landfill (Tipton, 2013).

Kao (2013) examined how designers could remake old, used products and materials, and how semiotics could analyze the refashioning of old products to explain how old products gain new value and significance. The redesigning of the used product would allow trash to be transformed into worth through a redesign, motivating greater reuse and recycle processes and products. It was confirmed that there exists a consumer segment willing to buy items that are not new from secondhand shops which will provide a good start for redesign marketing (Kao, 2013).

Foo (2013) proposed "renew-old" as a design paradigm in resolving the issue of excessive textile and clothing consumption through the reworking of used garments. Research was conducted in two sections—one dealing with theories and data collection from cities in Malaysia, Singapore, Hong Kong, and Japan, which involved questionnaires and interviews investigating the used clothing culture in the selected city; the second part of research consisted of actual refurbishing process carried out on the used garments, as reported by the interview subjects. The final goal was to demonstrate the practices of revitalizing old garments, for actual solutions (Foo, 2013).

5.4.5 Low-cost upcycling business

The Textile Recycling Association, India, which organizes secondhand clothing recyclers and distributors in Kandla, Gujarat, employs 3000 people every year. In Panipat, India, known as the "cast-off capital," is the location of 150–200 mills, which import discarded clothes from Western countries and convert them into recycled textiles. The industry employs around 20,000 people and takes in annual revenues

of $62 million, according to a report in September 2017 by All India Woollen and Shoddy Mills Association, a trade body ("shoddy" was originally a nonpejorative word for reclaimed fiber). The business appears fragmented, poorly organized, and almost wholly unregulated. One mill could create 10,000 kg of yarn a day from 20 tonnes of used clothes. The yarn is then used for making blankets, school blazers and red-and-black check fabric popular among the Masai people of Tanzania and Kenya. Goonj, a nonprofit organization in India, reuses cloth to make reusable sanitary pads for rural women. "Frip Ethique," an Oxfam-run social enterprise in Senegal, enables women workers to earn a decent living by sorting and selling clothes to local market traders (Hanging by a Thread, 2017).

Mundkur and Dedhia (2014) had done a field survey and the data were gathered through the personal interviews with the *bhandivale*, a class of roving used clothing merchants, who were from different localities of the western and eastern suburbs and Central Mumbai, India. The study revealed that *bhandivale* were involved in collecting redistribution of postconsumer waste for a living. Most *bhandivale* belonged to the age group of 21−50 years and lived with the larger family and survived by collecting old goods by exchange of stainless steel utensils, plastic ware, or money from residential areas.

Goldsmith (2012) focused on the growing phenomenon of textile recycling in New York City. Interviews with some of the hundreds of individuals in Union Square Greenmarket in Manhattan who drop off thousands of kilos of materials for recycling shed light on their purpose for doing so. People were bringing their clothes for recycling because of their desire to be eco-friendly, and no one expressed any disagreement with the assumed positive ecological value of textile recycling. There was little or no evidence that bringing in textiles for recycling might decrease the overall consumption of textiles, but the suggestion favored was that if the recycled materials are industrially produced or the clothing of recycled material was widely made available, it may reduce the impact on the environment (Saville, 1999).

Myers (2014) reported that upcycling is one way for designers and manufacturers to recycle textiles wherein secondhand fashion is deconstructed and reconstructed into current fashion. Views of 20 women, ages 25−65, were taken about how they recycled their discarded clothing and whether they would be open to buying secondhand clothes. In their study, women reported that style and price were more important than environmental causes in their upcycled purchases. The study revealed the value of upcycling, recycling, and donation of clothes, i.e., secondhand clothing, to avoid the impact on the environment and could be an opportunity to binge on fashion (Myers, 2014).

Adivarekar and Suchitra (2009) studied the disposal of waste strictly avoided through the use of recycling technology. They shed light on the recycling industry, on the scope of recycling through various mechanical and chemical processes with respect to an energy saving perspective, and also emphasized the importance of recycling behavior through micro and macro behavior of recycled goods. Their study showed the clothing market of apparel accounts for approximately 48% and conversion to value-added clothes makes up for 29% of the total volume of reclaimed goods (Adivarekar and Suchitra, 2009).

Torstensson (2011) gave an overall idea about the upcycling of the goods. The problems occurring during the upcycling and causes of the overconsumption of goods were analyzed. A theoretical framework was devised with a number of questions like why companies choose to offer upcycled textile product, their selling potential, and consumer attitudes, etc. for analyzing the impact of upcycled textile products on the environment by finding out the consumers' and vendors' motive and challenges faced to upcycle the textile goods in terms of trademark infringement and labelling of the upcycled garments. The analysis also considered the significance of price, strategy to change the thinking, environmental aspects, etc (Torstensson, 2011).

5.4.6 Consumer attitude toward new textile garments

This survey reviews the modern consumers' buying behavior of the textile brands and their eco-friendly angle in India and also gives its impact on sales promotion tools. The consumer's perception of various aspects of purchasing apparel products related to brands, eco-friendly clothing, and fictitious brands has been revealed in this survey. The survey was carried out across all classes of society like students, working, nonworking, and retired groups in the age group range of 15−70 years. The consumers frequently purchased a new clothing item and planned to buy more in the future as per the necessity. They looked upon quality and comfort as major aspects while buying a clothing product. A comparable amount of people observed brand as a factor while shopping for clothes. Many people prefer on-site shopping compared with online purchase and wished to have variety in their apparel shopping habits. Nowadays, modern consumers tend to buy branded and eco-friendly apparels and home furnishing materials. The conducted survey informs that the consumers are aware of fake or fictitious brands. The results of the study indicated that quality is the most important attribute of apparel from a consumer's point of view followed by comfort, cost, and brand factors. Half of the surveyed consumers were unaware of the eco-friendly angle of the brand, but when explained, consumers were ready to buy the "green" or "eco-friendly" textile material by paying extra 5%−10% of the price. The information gained from this survey would help apparel manufacturers and retailers to understand selection criteria for consumers while purchasing new or upcycled apparel.

Also, the study (Teli et al., 2016) was conducted to analyze the behavior of consumer's most preferred clothing, shopping frequency, shopping preferences, level of consciousness about various apparel brands, awareness about eco-friendly angle of brand, fictitious or fake brands, and their expectations from various clothing materials made from various fibers. Considering the adverse effects of textile manufacturing on the environment, of the total 296, 44.9% (133) consumers showed interest in buying eco-friendly products at a premium, while 13.2% (39) were not at all ready to pay an extra cost for eco-friendly textile materials. A total of 31.1% (92) respondents were ready to pay 5% extra, whereas 9.8% (29) were willing to pay 10% extra. This showed the existence of a ready market for willingly buying upcycled, eco-friendly textile products.

5.4.7 Low-cost sustainable upcycling based on waste biomolecule sources

When considering the upcycling of used and secondhand clothing, redyeing and refinishing are important components. A low-cost sustainable solution for achieving the same is through the coloration and finishing of textile materials made possible with the different natural resources derived from plants such as *Delonix regia* stem shell extract (wood worker waste), *Sterculia foetida* fruit shell extract (jungle and roadside waste), banana pseudostem sap, green coconut shell extract (waste of water/sap molecules), roasted peanut skin, where an agro-processing residue can be utilized as a natural source of colorant for textile materials. The dyed textile materials have shown effective antibacterial activity against *S. aureus* and *E. coli* bacteria as per the AATCC 100 test method. These waste extracted biomolecules also showed good ultraviolet protection properties on a textile fabric. The idea of using naturally occurring resources from green coconut shell extract for flame retardant finishing of textile materials, simultaneous with other properties such as ultraviolet protection, antibacterial, and coloration with low cost for cotton, jute, and wool fabric, is relatively new. Flame retardancy in the plant-based biomolecule-treated textile material is caused by inorganic metal salts, metal oxides, phenolic groups, etc., which helped in the production of more char and nonflammable gasses. Such a sustainable research approach might lead to excellent value addition through the upcycling of the textile fabrics from waste biomolecules. Thus, the use of waste stream plant natural resources for imparting functionality to textile substrates is applied in various areas like military tents, public halls, theatre, sofa cover, bags, table lamps, curtains, and other decorative products in the home textile and protective textile segments. Thus, it offers a feasible alternate path to upcycling the engineering applications of textiles (Teli et al., 2017; Teli and Pandit, 2017a,b,c,d, 2018; Pandey et al., 2017).

5.5 Challenges and opportunities for textiles and fashion

5.5.1 Challenges for textile and fashion

Recycling is essentially downcycling as it degrades the material condition over time. Recycling of textile take place at the step where it goes to charities, deteriorates to use in other materials or reuse, but overall, the merit of the material will reduce over time. Most products were not suitably designed for recycling, which makes recycling not very ecologically benign. Downcycling is not a pathway for success in the long term. Upcycling is possible as long as there is waste available.

The need for new items according to the mindset of the consumers has characterized the designing of products by the current fashion industry, leading to overconsumption. The fundamental idea of upcycling is when a product is bought once before it is

repackaged into another new form of consumption while giving the benefit of being ecologically conscious. Upcycling permits consumers to use a material more than once, instead of "use and throw" (McDonough and Braungart, 2002, 2010).

Branding is critical to the marketing of textile commodities. Textile brands are associated with perceptions, images, experiences, and attitudes to connect to the brand image through a symbolic construct developed in people's minds, consisting of the information and expectations associated with the product. Quality perceived is influenced by the consumer's judgment about a product's overall merit and caliber (Zeithaml, 1988). The value for money and expectations of the quality product are features which sustain the authenticity of the product. Branded garments are often preferred over nonbranded garments because the former offer superior quality. People tend to be faithful to brands that earn their rational and ethical trust as well as their liking. Consumer awareness is the understanding of the rights as a consumer concerning available products and services being marketed and sold. Brand consciousness is one part of consumer awareness.

Awareness about the environment has also seeped into consumer's mindset. In recent years, environmental and social issues have been taken into account by consumers while purchasing products. Sustainability is observed, when paired with corporate social responsibilities, informed purchasing decisions, motivated by an emerging green orientation at some companies. Eco-clothing and eco-fashion support designs which do not only tailor, shape, and drape but also consider the clothing's social and environmental life cycle, from the cultivation of its fibers to its use and ultimate disposal. Purchasing an eco-friendly clothing is a subset of environmentally conscious behavior (Joy et al., 2012).

Life cycle−based environmental impact assessment (ANSI/ISO 14040, 2006) has as its objective the identification of favorable and damaging environmental impact of a product at every step of its life cycle (Organization IS, 1997). The environmental effect of a sample test garment's life cycle showed the whole life cycle consumed 76 MJ of energy, emitted more than 6 kg of CO_2, and used more than 230 L of water. More than 3 kg of solid waste resulted including lesser amounts of other waste, including hazardous waste.

Textiles manufacturing processes like warp preparation, weaving, dyeing, printing, finishing, and quality and process control generate waste like fiber wastes, yarn spinning waste (hard Fiber), off cuts waste, packaging, and spool. Also wet finishing processes use up to 200 L of water/kg of fiber making water polluted. According to the data of the textile waste collected by Bangalore Metropolitan Transport Corporation (BMTC), 2012, Fig. 5.7 shows that maximum waste of 36% is from apparel and 34.4% from fabrics (Agrawal et al., 2015).

Waste minimization at the source is the more sensible and sustainable approach to handling solid waste in urban areas, through a continuous improvement in recycling technology. The recycling industry in India suffers from (1) lack of organization where the current system of reuse and recycling is highly labor oriented, (2) absence of compliance with regulatory environmental requirements in the processing done by small-scale industries, (3) unhygienic working conditions at the Kabariwala Complex and recycling factories (APO, 2007).

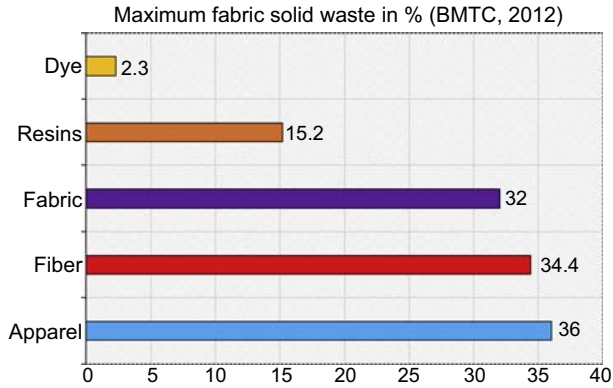

Figure 5.7 Maximum fabric solid waste from Bangalore.

Socially and environmentally friendlier textiles might cause costlier finished products; some consumers may consider sustainable garments to be ugly or unfashionable, with the design and the appearance of eco-clothing being unappealing, though that is changing with luxury, high-end recycled products (Consumer). The market for recycled garments and fibers is in the nascent stages due to deficient take-back systems and lack of suitable and well-advertised drop-off locations for unwanted clothing/textiles in many countries, which ends up causing serviceable garments to be buried in landfills or burnt.

5.5.2 Opportunities in textile and fashion

Natural fibers such as cotton, wool, etc. are somewhat difficult to upcycle as the more numbers of fibers are pulled and torn from the clothes, the weaker and shorter fibers become responsible for degrading the quality and finally become unstable for clothing applications.

One should attempt to minimize the number of materials used, increase the longevity of product life by reusing it and, once a product has reached the end of its useful purpose, recycle its constituent parts. Along with this, there is an addition of a new "R," "Rethink," which encourages individuals to consider sustainable options. Rethinking means that the designer concerned with presenting a product should continually search for sustainable options and designs. Without sacrificing the performance of the finished product, the designer needs to target reduction in water and energy resources expended in the manufacturing process. Designers should maximize utilization of materials from renewable sources while changing the mindset of in-built "obsolescence" (Remy and Huang, 2015).

There is a need to convince people to buy refurbished goods because most people would not prefer to buy used clothes which were already used by someone else. Hence creating the general awareness about textile wastes and its impact on the environment by collecting statistical data from the analysis of life cycle assessment of upcycled goods are important to eliminate/minimize the defects and reuse the objects with

minimum cost involvement. Also, cost estimation comparison should be carried out between upcycled product against the cost of conventional product manufacturing and from the saving point of view. Upcycling of the goods or articles can be tried out for a number of products by incorporating technological interventions and making the upcycled goods acceptable to the consumers.

There are many benefits and opportunities to upcycling old materials into new products or usable parts. Similar to recycling, upcycling prevents the termination of resources in landfills, saves energy, decreases ecological toxicity, and helps promote the growth of local economies and create jobs. The recycling industry in India generated more than $14.1 billion in revenue per year and an annual payroll of $2.7 billion. It supports almost 170,000 jobs throughout the country, which helps to create local income and stimulate the local economy (Remy and Huang, 2015). It saves landfill space by rerouting the products, which are discarded into landfills which affords a penalty to society by consuming valuable lands. Upcycling helps reroute resources from landfills and incineration into upcycling process industries. Opting to buy recycled clothing, for example, helps to release 5% of landfill space. It helps save the natural resources like forests, mountains, and oceans, which exist in a delicate balance and now need to be saved from being overused for their wealth. Upcycling helps achieve reuse of materials that are already linked into the value chain rather than gathering virgin resources. Upcycled materials instead of creating new products from virtually fresh resources always save energy and reduce the climate damage from the carbon footprint of those products. There are more advantages to upcycling, similar to those found in the recycling industry; these should reveal the tremendous capacity upcycling has to salvage some of the world's biggest environmental problems. By adding, removing, or introducing a new design, upcycled clothes save great money. With the secondhand clothing stores, upcycling status can be improved. The greatest benefits of upcycling were to save the earth's resources by reusing the old goods. The scraps of material left after upcycling could also be recycled.

Since 2013, Pure Waste Textiles, a Finnish company run by Jukka Pesola and Anders Bengs is producing mass quantities of fabric, made from recycled materials. Instead of using sustainable fabrics, usable clothing is produced from 10% to 15% extra fabric which goes into the trash in textile factories. Their new unit in Tamil Nadu lets them break down knitted fabric to fibers once again. Once the material is carded, it is spun and turned into a new knit. Given that the material is predyed, it eliminates another wasteful step in manufacturing clothes: dyeing. By repurposing material and sewing it at a nearby location, the company attempts to make a streamlined manufacturing process that is low on its carbon footprint, cost-effective, and easier to manage. Their Indian business partner runs the sewing unit where the garments can be sewed and finished. The tees, sweaters, and pants they produce out of excess or waste textiles are fashionable and well cut staples and do not appear recycled to consumer perception. On client demand, they make branded or custom-designed apparel from their recycled materials. Already, Pure Waste Textiles has developed an annual turnover of 1 million euros. With a team

of 10 in Helsinki, 5 in Mumbai, and 200 in Tamil Nadu, recycling is a profitable expanding business, providing beneficial employment to local populace, while eventually being fueled by renewable energy, such as wind and solar power (Circular Economy in India, 2016).

New textile sorting technology which has come into vogue also helps in the recycling process. The European Union project had developed a device to automatically separate unwearable textiles by chemical composition and color, giving birth to a new market for low-quality textiles. The textiles were shredded and spun into new yarn, which was woven for use in creating new clothes. New textile sorting technology makes new clothing out of old textiles. A Dutch organization "Textiles 4 Textiles" developed a process to convert low-grade textiles into new garments, by means of a sorting machine using funding from the European Commission's Eco-Innovation Programme. The machine segregates the lower grade material into separate streams applying near infrared detection/scanning technology that determines the material composition, color, using air-stream technology to blow it into the assigned bin. The machine could sort up to 4000 tonnes of textiles annually (Chhabra, 2016; Alkazam, 2013).

The benefits of recycling textiles include the contributions to charities and clothing for the poor. It provides support for people affected by natural and man-made disasters. It minimizes the solid waste assigned to landfills. It applies sustainability and environment conservation and decreases carbon footprint. It accelerates economic development globally. It modifies the waste material into value-added products and also gives employment to partly skilled or unskilled labor.

5.6 Conclusion

Upcycling is essential as an alternative for manufacturing new products to satisfy the increasing requirements of the consumers. If the demand will not reduce, it has to be fulfilled, and since new production will only sustain the destructive cycle of overconsumption and its attendant damage, the demand has to be met by new products made of preexisting materials. On the other side, the purchasers' quoted price is highly influenced by psychological factors as to whether the individual consumer chooses to buy a product made from a virgin material or upcycled resource. Upcycling is not only a sustainable process but also has strong financial profitability if properly employed. Upcycling is a much greener way of recycling and beneficial environmentally. By using already existing waste materials, the utilization of freshly retrieved raw materials for new products is decreased, which can minimize energy expenditure, air pollution, water pollution, and CO_2 emission. Humankind has generated an overabundance of clothes through textile manufacturing, and it is in our hands to bring an end to the old, unsustainable form of the industry. Current challenges to the environment, market status, and outmoded but still existing paradigms ranging from the manufacturer to consumer attitude need to be overcome on the pathway to a circular economy.

References

Adivarekar, R.V., Suchitra, P., 2009. Reuse and recycling of textile solid wastes. Journal of the Textile Association 70 (3), 118–126.

Agrawal, R., Sharan, M., 2015. Municipal textile waste and its management. Research Journal of family, Community and Consumer Sciences 3 (1), 4–9. ISSN 2320–902X.

Alkazam, A., 2013. Sorting technology from T4T can help improve recovery and efficiency. Journal of Textile Science and Engineering 3, 136. https://doi.org/10.4172/2165-8064.1000136.

Bell, N.C., Lee, P., Riley, K., Slater S. Tackling Problematic Textile Waste Streams. Oakdene Hollins Ltd, Aylesbury, UK. https://ec.europa.eu/easme/en/news/circular-economy-practice-reducing-textile-waste.

Bianchi, C., Birtwistle, G., 2010. Sell, give away, or donate: an exploratory study of fashion clothing disposal behaviour in two countries. International Review of Retail Distribution and Consumer Research 20, 353–368.

Brones, A., November 18, 2016. Fashion Brands Innovating with Textile Waste.

Caine, T., June 2010. Recycling vs. Upcycling: what is the difference. Intercon 3, 2011. Viewed.

Carmichael, A., 2015. Man-made fibers continue to grow. Text World 165, 20–22.

Chhabra, E., July 28, 2016. India: Two Entrepreneurs Turn Waste into a Business. Forbes. https://pulitzercenter.org/reporting/india-two-entrepreneurs-turn-waste-business.

Circular Economy in India, December 2016. Rethinking Growth for Long-term Prosperity, Ellen MacArthur Foundation with the United Nations Conference for Trade and Development (UNCTAD) as Knowledge Partner and Funded by Climate Works Foundation.

Claudio, L., 2007. Waste couture: environmental impact of the clothing industry. Environmental Health Perspectives 115, A449.

Mathews, B., 2015. Closing the Loop: Can the Apparel Industry Move from a Linear to a Circular Business Model, an Essential Guide for the Global Textile Supply Chain. MCL Global.

Comley, B., 2007. Peer review in the context of regional integration. Econ Round-Up 17.

http://www.bsr.org/reports/BSR_NICE_Consumer_Discussion_Paper.pdf.

Data according to Secondary Materials and Recycled Textiles (SMART) Association, 1932. The Association of Wiping Materials, Used Clothing and Fiber Industries Since, p. 6.

De Brito, M.P., Carbone, V., Blanquart, C.M., 2008. Towards a sustainable fashion retail supply chain in Europe: organisation and performance. International Journal of Production Economics 114, 534–553.

Towards More Sustainable Consumption: Industrial Product Lifetimes and Restoring Trust through Consumer Information, 2013. EESC, Brussels, Belgium: Europe Union.

Ellen MacArthur Foundation, 2017. A New Textiles Economy: Redesigning Fashion's Future. http://www.ellenmacarthurfoundation.org/publications.

http://ec.europa.eu/environment/europeangreencapital/clothing-waste-initiative/.

Farrer, J., 2011. Upcycling in fashion design., Estonian Academy of Arts Tallinn (Ph.D. thesis).

http://www.chicagotribune.com/sns-fashion-recycled-jeans-story.html.

Foo, A., 2013. The New Old: A Post Fashion Consumption Practice.

Goldsmith, D., 2012. The Worn, the torn, the wearable: textile recycling in union square. Nord Text Journal 1.

Gwilt, A., 2011. Shaping sustainable fashion: changing the way we make and use clothes. Routledge.

Hanging by a Thread, September 2017. Panipat, the global center for recycling textiles is fading. The Economist 424 (9057), 56.
Joy, A., Sherry Jr., J.F., Venkatesh, A., Wang, J., Chan, R., 2012. Fast fashion, sustainability, and the ethical appeal of luxury brands. Fashion Theory 16, 273−295.
Kao, T.M., 2013. One Person's Trash Can Be Another Person's Treasure: Redesigning Used Objects.
Khan, M.A., 1995. Concepts, Definitions and Key Issues in Sustainable Development: The Outlook for the Future.
Klepp, I.G., Laitala, K., Schragger, M., Follér, A., Paulander, E., Tobiasson, T.S., et al., 2014. Sustainable textile initiatives and suggestions for a Nordic Roadmap.
Lewis, T.L., Park, H., Netravali, A.N., Trejo, H.X., 2017. Closing the loop: a scalable zero-waste model for apparel reuse and recycling. International Journal of Fashion Design, Technology and Education 10, 353−362.
Macomber, J.D., Carr, C.M., Zhao, F., 2011. Sound Group China: Urban Waste Entrepreneurs.
McDonough, W., Braungart, M., 2002. Design for the triple top line: new tools for sustainable commerce. Corp Environmental Strategy 9, 251−258.
McDonough, W., Braungart, M., 2010. Cradle to Cradle: Remaking the Way we Make Things. North Point Press.
Morgan, L.R., Birtwistle, G., 2009. An investigation of young fashion consumers' disposal habits. International Journal of Consumer Studies 33, 190−198.
Mundkur, Suman, Ela Dedhia, 2014. Occupational Details of Collectors of Post-Consumer Clothing Waste in Mumbai.
Myers, G.J., 2014. Design and Selling Recycled Fashion: Acceptance of Upcycled Secondhand Clothes by Female Consumers, Age 25-65. Circulation 701, 8888.
Niinimäki, K., 2014. Sustainable consumer satisfaction in the context of clothing. *Product-service system design for sustainability* 218−237.
Niinimäki, K., 2015. Ethical foundations in sustainable fashion. Textiles and Clothing Sustainability 1, 3.
Nilsson, M., Varnäs, A., Kehler Siebert, C., Nilsson, L.J., Nyqvist, B., Ericsson, K., 2009. A European ecoefficient economy - Governing climate, energy and competitiveness. (Report for the 2009 Swedish presidency of the Council of the European Union). Stockholm Environment Institute.
OECD Observer Policy Brief, January 2007. Improving Recycling Markets.
Organization IS, 1997. ISO 14040: Environmental Management-life Cycle Assessment-Principles and Framework.
Pandey, R., Patel, S., Pandit, P., Nachimuthu, S., Jose, S., 2017. Colouration of textiles using roasted peanut skin-an agro processing residue. Journal of Cleaner Production 172, 1319−1326.
Patel, D., Pandey, R., 2015. Textile recycling practices prevailing in Kanpur city. International Journal of Community Science and Technology 1, 1−10.
The Recycler, May 2016. Circular Economy Knowledge "High" in US Business. http://www.therecycler.com/posts/tag/circular-economy/.
Remy, C., Huang, E.M., 2015. Limits and sustainable interaction design: Obsolescence in a future of collapse and resource scarcity. First Monday 20.
Report of the APO Survey on Solid-Waste Management 2004−05, 2007. Solid Waste Management: Issues and Challenges in Asia. APO, ISBN 92-833-7058-9.
Saville, B.P., 1999. Comfort in Physical Testing of Textiles. The Textile Institute.
Staniškis, J.K., 2012. Sustainable consumption and production: how to make it possible. Clean Technologies and Environmental Policy 14, 1015−1022.

Teli, M.D., Pandit, P., 2017a. A Novel Natural Source Sterculia foetida Fruit Shell Waste as Colorant and Ultraviolet Protection for Linen. Journal of Natural Fibers 1–7.
Teli, M.D., Pandit, P., 2017b. Development of thermally stable and hygienic colored cotton fabric made by treatment with natural coconut shell extract. Journal of Industrial Textiles, 1528083717725113.
Teli, M.D., Pandit, P., 2017c. Multifunctionalised silk using Delonix regia stem shell waste. Fibers and Polymers 18, 1679–1690.
Teli, M.D., Pandit, P., 2017d. Novel method of ecofriendly single bath dyeing and functional finishing of wool protein with coconut shell extract biomolecules. ACS Sustainable Chemistry and Engineering 5 (9), 8323–8333.
Teli, M.D., Pandit, P., 2018. Application of *Sterculia Foetida* fruit shell waste biomolecules on Silk for aesthetic and wellness properties. Fibers and Polymers 19, 41–54.
Teli, M.D., Valia, S.P., Maurya, S., Shitole, P., 2014. Sustainability Based Upcycling and Value Addition of Textile Apparels.
Teli, M.D., Metkari, A., Pandit, P., 2016. Awareness among modern consumers about textile and apparel brands & their eco-friendly angle. Journal of the Textile Association 77 (1), 33–42.
Teli, M.D., Pandit, P., Basak, S., 2017. Coconut shell extract imparting multifunction properties to ligno-cellulosic material. Journal of Industrial Textiles, 1528083716686937.
Textiles Market Situation Report, 2016. WRAP (Waste and Resources Action Program): Banbury.
Tipton, J.D.K., 2013. Exploring the Process of Deconstruction of Used Garments in Development of a New Method Called Tattering.
Torstensson, R., 2011. A New Player in the Accelerating Textile Industry-upcycled Textile Products.
Wai Yee, L., Hassan, S.H., Ramayah, T., 2016. Sustainability and philanthropic awareness in clothing disposal behavior among young Malaysian consumers. Sage Open 6, 2158244015625327.
Wang, J., 2011. Upcycling Becomes a Treasure Trove for Green Business Ideas. Entrepreneur Magazine 22.
WCED, 1987. Our Common Future World Commission on Environment and Development. Oxford University Press, Oxford.
Zamani, B., 2014. Towards Understanding Sustainable Textile Waste Management: Environmental Impacts and Social Indicators.
Zeithaml, V.A., 1988. Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence. Journal of Marketing 2–22.

Further reading

Zitting, J., 2017. Optical Sorting Technology for Textile Waste: Development of an Identification Method with NIR Spectroscopy.

Circular economy: a necessary (r)evolution

6

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6.1 Introduction

Take, make, and dispose. The slogan of our consumptive society does not seem to be very sustainable. Fortunately, the status quo is up for a change: long-lasting design, repair-communities, and recycling are becoming a trend of modern society. Many industries now attempt to reconcile industrial production with the protection of the physical and human resources available today and for the generations that will follow. From this point of view, great importance is given to reducing the consumption of raw materials, waste during production, and waste at the end of life of products. In a circular economy, the industry is regenerating itself through slowing, narrowing, and even closing energy leakages. Diversity and clean production methods are becoming inevitable for vertical brands. To apprehend this trend, the industry of textile and fashion is a relevant field to understand this economic evolution at a global scale. However, is our current lifestyle adaptable to a circular economy? Is it the optimum economic model we have been looking for so long? Many examples and initiatives demonstrate why a circular system is, not only relevant regarding the evolution of our world but also necessary for a sustainable business development, offering new perspectives. Therefore, this paper addresses those crucial elements that in the future will become an economic, a social, and even an environmental necessary change with respect to the perception and use of resources, both from the individual and corporate points of view.

6.2 Breathless model and resources

6.2.1 The 21st century is the society of excess

Here we are going to look at our contemporary society, which is precisely distinguished through an over production and consumption, higher desires to purchase and own. These specific tendencies will be seen as defining key aspects of social organization, style of production, and consumption.

Our society can be defined as the "society of excess," where too much has become normal and the sense of measurement and limits are something archaic.

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00006-6

This type of social formation, now structured as a real system, represents the hypermature phase of the consumer society, characterized, on the one hand, by a continuous, generalized, and fast quantitative growth (involving goods, markets, and people); and on the other hand, by almost disappearing of the traditional categories of reference of our material and relational existences. Our social structure completely lost the sense of measure and now we no longer have the landmarks that guide our choices and our opinions.

In fact, extremes have the wind in their sails: far or near in our network society (Internet, mobile phones, iPod, iPad, etc.), where you can be virtually in more places but were in the same place as a hypermarket, there are more than 40 thousand product references; where global and local, due to the main effect of globalization and internationalization, have become relative concepts (economic and geographical); where jumbo jets become gigantic, skyscrapers are taller, and shopping malls endless. At the same time that notebooks become smaller and lighter and the infinitesimal smallness of nanotechnologies is affirmed.

Our excess society is definitely in a context where it is crucial to do more and more in less and less time. In this situation, in fact, there is no social phenomenon, economic sphere, productive sector, consumption methods, or daily practice that does not present anomalous growth. Either that you are in a car or watching television, at the table or on the beach, in a conference or a snack bar, in-flight or struggling with a shopping cart, the reality with which we must deal is invariably marked by enormity.

And of course, our economic model is driven by this polarized society. Companies are applying the most efficient model to respond to this increasing demand of novelties and to insure a perpetual consumption. The social status is now measured by the amount of goods you can consume, how many luxury items you can buy, how big can be the car that you purchase. That is why we only focus on the present acquisition: buy, use today, and throw it tomorrow. New cell phone every year, new clothes collection every 6 months, and what happen to those products after? Most of us did not think that question about 10 years ago.

We are at a turning point in the social organization. The circulation of information and communication around the world pushed everyone of us to think about these questions. We realized that our economic model is the central point of the way we consume, and our consumption is the perfect reflection of this society of excess.

For most of human history and long before they were mass produced, clothes were handmade and fitted by either tailor for the rich, or self-made by the poor. The industrial revolution and, later on, the rise of ready-to-wear encouraged people to buy more and more clothes, for a cheaper price but a lower quality of fabric and fit. The fierce and increasing competition in the fashion industry encouraged a faster and disposable fashion along with shorter and shorter fashion cycles. The rise of fast-fashion brands (or "disposable fashion"), such as ZARA or H&M, changed the formerly standard 6-month waiting after the catwalk, to just a matter of weeks.

This quick response to the trends enlightened during the fashion shows provides the freshest products for the shortest time, thus making them less durable as the next collection will replace them over the next few weeks.

During the manufacturing process, around 10%−20% of all textile products are wasted Pensupa et al., 2017.

Each year, 600,000 tons of clothing are marketed each year in France, out of which only 20% will be recycled Eco Tlc, 2016. Fast-fashion countries such as the United States or the United Kingdom generate an even bigger amount of waste every year: 12.4 million tons (Association SMaRT, 2011) and 1 million tons (Lyons, 2017), respectively. Hong Kong generates approximately 350 tons of textile waste daily (Waste Reduction, 2016).

Disposable fashion therefore generates a constantly growing amount of waste, exacerbated by an expanding demand for fibers by about 3%−4% a year. The global textile and apparel market is predicted to exceed 100 million tons by 2020 (Lyons, 2017).

Furthermore, preconsumer waste has been enlightened recently with the incineration of reject clothes by brands such as H&M, with more than 12 tons of clothing burnt per year in Denmark only. Those clothes were said to be production errors (moldy tee shirts, labels contaminated with lead), emphasized as a last resort only. However, the incineration of clothes is not only always due to a quality control failure but also to unsold stocks. Luxury brands often struggle with this issue and try to shed their unsold stocks without fear of breaking away from their image. After attempting to get rid of this stock through VIP destock sales, the last resort is still incineration. Luxury brands such as Hermes, Prada, Vuitton, or Dior are said to do so.

As our society reaches the breaking point of its consumption reality, our whole system faces a great challenge: find a new economic model at a global scale. This reality leads us to a deeper analysis on the driving forces, which are at the center of this economic development issue.

6.2.2 Raw materials are not the starting point of processes anymore

The fragrance industry is always striving for quality; however, it is becoming increasingly difficult to keep a regular supply of materials or maintain strong relationships with suppliers while still thinking about sustainability. This industry is the perfect example of why the increasing scarcity of raw material is a big challenge for many industries. The whole process of fragrances is based on the raw material and the extract of essences that will compose the perfume, and the fragrance industry uses large quantities of raw materials to generate the essence that goes into its products.

Several key crops are already in short supply including Madagascar vanilla, patchouli, sandalwood, and vetiver. The world famous fans made in Suzhou are now lacking the precious sandalwood, putting at danger one of the most famous handcraftsmanship in China after more than a thousand years story. An article, focused on scarcity of precious supply (Vulser, 2018) explained that none of the three biggest players of the industry has immediate plans to invest in growing the materials rather they see it as a separate business. Even if the public is always looking for all-natural ingredients, the reality is that the majority of perfumes contain synthetics. Despite our

negative perception of synthetics, some argue that they might be greener than using natural ingredients in perfumes: hectares of land are being used to gain such a small quantity when to an untrained nose you cannot smell much of a difference between the natural or synthetic essence (Vulser, 2018).

The quality and cost of the raw materials used in perfumes is constantly changing due to a number of factors (sun, rainfall, temperature, soil, natural disasters, politics, disease, climate, or agriculture). As the temperatures are rising, flowers are emitting less fragrance. Climate change will have a significant effect on raw material crops in future decades. Therefore, it is now obvious that the sustainability of this kind of industry is threatened by the current evolution of the environment. However, a key player in this field, the French luxury group Louis Vuitton Moët-Hennessy (LVMH), has launched a program based on growing vetiver based in Haiti to prevent soil erosion and restore damaged areas. They have also focused on sustainable development by replanting upwards of 10,000 orchids in China since 2009. In the coming years, it is imperative for companies to adapt their work to the changing climate caused by global warming.

These concerns become even more accurate when it comes to dealing with natural raw materials from animal sources such as musk, civet, castoreum, beeswax, hyraceum, and the world famous ambergris. The Washington Convention and the elaboration of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) drafted as a result of a resolution adopted in 1963 at a meeting of members of IUCN (The World Conservation Union), from 1973, has been playing the catalytic role the whole world had been waiting for so long. The leather market, the fur market, could therefore be also considered as precursors in that field. Preservation areas around the world such as the Ngorongoro caldera in Tanzania, we have been having the chance to be visiting with some officials, are also contributing to that societal shift.

6.2.3 Water, the resource for excellence

Analyzing the articles published in the press and the forecasts for tomorrow, it is immediately clear why many experts say that future crises will no longer affect oil, but water as a resource. Water is an essential resource for life, and at present, it is increasingly getting scarce in quantities, and it requires a responsible and sustainable management.

The possibility of a gradual exhaustion of this resource par excellence, associated with the consistent price increase expected, is a concept not yet known to all—even in Europe, a relatively rich continent of water. Each of us must realize that without electricity, we can resist longer, but without water, we would survive only a few days.

There, we could be considering the hospitality sector as being one of the key major players in terms of consumer-based sensitivity, a definitive role which has been opening the battlefield for this specific advocacy communication and for a greater kinetic of diffusion of such predominant mindsets, a kind of tremendous impact like the one which has been monitored at the times the first “non-bloody diamonds” got sold

when the Unita's leader in Angola, Jonas Savimbi, had been making the world knowing about their existence a few years before his death in 2002.

The hospitality sector, the hydrotherapy, the thalassotherapy have been boosting this circular economy evolution.

In Portugal, the so-called "resorts with a new attitude," whose motto is "blue & green," like the marvelous jewel in the Algarve region, the Vilalara Thalassa Resort in Algoa is definitely playing a great leading experience in the field, fully using the opportunities given to this country by the Atlantic Ocean—rich background. That is also the case at the Cascais Miragem Hotel even when hosting some prestigious conferences. Our friend Christophe Moquet is even heading an MSc program in Science, Conservation, and Valorization of Marine Resources "MARRES" at Skema and with the UCA Nice, some years after the first loud signals sent by Paul Ricard, Jean-Yves Cousteau, or Ellen MacArthur.

In Belgium, from the original city of Spa, this deep knowledge and understanding of a circular need for water has even been teaching to some companies, such as Eytelia or Sil'innov, to be circular by essence, to rebalance and energize their understanding of sustainability, whether for the environment or for human beings themselves. From detritic sands to bio-activated silicium, nature and health have never been contributing to such an obvious demonstration of clever achieved efficiency.

In Italy, the marvelous experience of pure achieved sustainability can be felt at the Palazzo di Varignana Resort & SPA, in the close neighborhood of Bologna. From the rooms themselves to the fantastic cuisine of the restaurant, with olive oil and vegetables coming from the own farm of the resort, with locally grown products, "Il Palazzo Restaurant" is devoted to "awaken you senses." The chef is "devoted to our vegetables garden, an indestructible source of inspiration." The "solidarity dish" in this gourmet restaurant enables guests when choosing this dish to donate to the national campaign "Restaurants against hunger" helping malnourished children from 50 countries of the world. As mentioned upon arrival, there, guests are to be experiencing a pure "sense of wonder."

In India, the Neemrana Hotels, founded in 1991 by our friend Aman Nath could be also considered as major game changers. These "nonhotel Hotels" are respecting the full circular culture of the buildings, the inner decoration, the catering, and the water cycle of the different related activities. We owe the greatest admiration to Aman Nath and to Francis Wacziarg who decided some 30 years ago, to be choosing such a long-term orientation whether in Cochin, at Vasco de Gama's former house, or at the world famous Neemrana Fort Palace.

In Tanzania, the best sugar cane company, the TPC (Tanzania Planting Corporation in Moshi), which is even producing its own power supply by means of recycled cane biomasses, is able to take care of the 2500 employees, from heating to feeding, and with even a wonderful golf course in front of the Kilimanjaro. There, wasted water does not exist anymore. The real green attitude, which we could have been enjoying from inside when visiting our friends Eric Pignon and Pascal Petiot with some avant-gardist circular technological innovations.

In a globalized scenario, this expression of popular wisdom gains even more importance and is being used more and more often. More than 1.2 billion people worldwide

suffer from thirst, and over 2 billion people do not have access to adequate sanitation. As mentioned by the International Olympic Committee, "Credibility, sustainability and Youth" must be at the heart of all coming decisions, and the Olympic Games should now be considered as a much more efficient lobby catalyst than many other programs or institutions, taking the opportunity to have an emotion better conveying platform with a tremendous press cover.

The time has come to invest in projects aimed at the sustainable management of water resources to ensure water supply to future generations. For complete management of water resources, we mean the efficient and rational use of water, as well as specific solutions for its treatment, regardless of whether it is sanitary water, rainwater, or drainage. To this end, economically developed countries need to adopt a series of reliable water supply, distribution, and purification strategies.

The rational consumption of water presupposes an all-round consideration of its cycle, from the source to the sampling point up to the use and recirculation of the wastewater for treatment. The United Nations has developed a dedicated program called "Water for Life 2005−2015," whose main objective is the implementation of programs and projects related to water.

In this context, it can be found the Water Directive promulgated by the European Union, which defines the standards for achieving an optimal level of water quality. Thus, a framework shared at European level is established for the implementation of a long-term sustainable policy of use and protection for all waters.

In the previous example of the fragrance industry, water is also a central question. The use, the waste, and the absence of purification process can cause serious damages to the environment. The amount released into the environment is usually much larger than what is being applied on skin, hair, fabric, or other products. For example, producers of washing powders estimate that 1% of the perfume stays on the fabric, meaning that 99% is released into the environment. The presence of fragrances in drinking water, streams, or lakes could adversely affect the health of people, animal, and plant life. Companies such as IFF try to minimize water waste by creating recycling systems to recirculate cooling water at their facilities.

However, most of the improvement in their water performance has been due to reductions in water usage rather than recycling. Daily, around 300 million Americans wash clothes with fragranced products that end up polluting water and air. Furthermore, laundry product fragrances accumulate in fabrics and are very difficult to remove.

Meanwhile, 2750 L of water is used to produce 1 kg of cotton fiber, out of which 2120 L are consumed and therefore will not be returned to the original water source after being withdrawn Global Average LCIA. According to the Wall Street Journal, there is a joke in China today that "you can tell what colors are in fashion by looking at the rivers." The chemicals contained in this water involve a specific treatment to reduce them before disposing of it to the environment. The toxic nature of those chemicals has become a great concern to environmentalists worldwide as they have a negative impact on all forms of life. Dyeing section contributes to 15%−20% of the total wastewater flow and, more generally, the World Bank estimates that 17 to 20% of industrial water pollution comes from textile dyeing and finishing treatment given to

fabric (Kant, 2012). A way to avoid wastewater from fabrics would be using chemicals that are less harmful for the environment in the production process, e.g., fennel leaves, mangrove bark, beeswax, aloe vera, potato starch, or even olive mill wastewater could be used in the treatment of textiles for a more ecologic production.

6.2.4 Resource protection and cost reduction

The production of textiles does not only generate wastewater but also solid waste. This waste is generated during the production and the consumption of clothes. The fiber production causes an important quantity of scraps that can later be recycled for non-fashion purposes such as the manufacturing of medical product materials. During the manufacturing of cotton, the wastes are organic, so they can either be used again for other fabrics or decompose in nature. On the other hand, post-consumer textile waste is due to the use of mixed fabrics (both organic and synthetic) as well as other nonbiodegradable substances. The recycling of clothes becomes more of a challenge, as finished fabrics are often dyed, and contain finishes and other additives as well. In addition to sorting fabrics types, other solid materials must be detached from most of the finished goods: zippers (made of plastic, coil, or metal), buttons (made of acrylic, wood, or seashells), or rivets (copper, nickel) are a challenge to recycle. In order to discard most of this solid mixed waste, the most common methods of disposal used are either incineration or landfilling (Gordon and Hsieh, 2007). They reveal useful in the matter of space, but the textile compounds resulting from it are more harming the environment rather than helping it. Until the last century, landfilling of solid waste from clothing was considered relevant, as most of the fabrics used were made of cotton and therefore biodegradable. With the increase in consumption of synthetic materials, incineration became a rather useful way to dispose of important amounts. Up to 95% of textiles landfilled, each year could be recycled (Pensupa et al., 2017). Unfortunately, incineration generates the emission of toxic substances that permanently damage earth and human conditions.

To improve the sustainability of textiles across their life cycle, from the designing to the end of use—and therefore preventing the use of such polluting solutions—the European Clothing Action Plan has been launched with an objective of significantly improving it by 2019.

Furthermore, dramatic events such as the Rana Plaza collapse have put the fashion industry in the spotlight over the last decades. The always-increasing pressure to complete orders on time in a fast-fashion and low-cost world has quickly decreased the working conditions of workers in developing countries. This condition has led to the collapse of the Rana Plaza, a five-story commercial building in Dhaka, Bangladesh. This building mostly contained clothing factories in extremely bad conditions, and its collapse resulted in the death of over a thousand workers. After this deadly disaster, the Fashion Revolution Day movement has been launched and, each year, web users are invited to take a picture of themselves with a garment, from which the tag is visible, and to post it on social media with the hashtag #whomademyclothes.

This has both the will to encourage brands to have a green supply as well as denouncing the bad behavior of other brands while showing what the real cost of

fashion is. In February 2018, over 200,000 Instagram pictures were posted with this hashtag. In addition, the International Labor Organization estimates that 170 million children are engaged in child labor, with many in the garment and textile industry. Once again, fast fashion can be the center cause of this figure. Pushing companies to find ever-cheaper sources of labor for short deadlines has encouraged factories to employ children, mostly, in countries, which are producing most of the garment industry such as India, Thailand, or Bangladesh.

6.3 From linear to circular

6.3.1 CSR, the magic letters?

Now companies are pushed to the wall on resources but also due to a behavioral changing within the society, that is to say, their own customers. Eco-friendly fashion (eco-fashion) is becoming more and more popular while consumers become more aware of the ecological concerns. The circulation of information in a globalized economy now prevents textile industry from hiding their supply chain and the production conditions. We are now lead by the idea of a reasonable consumption within the respect of environment, working conditions, and social justice.

The different scandals and reports made on the polluting side of the textile business have changed the perception of people and their key factors of consumption. They are more involved in an eco-friendly trade market, and they really look at the backstage of what they used to buy. Child labor and working conditions remain the main CSR concern for customers and some companies have found the right manner to use this as an advantage. Because people are looking for a more respectful process of production, some actors used these elements as a powerful marketing tool. Highlighting your CSR efforts become a way to distinguish yourself and create an added value to your product.

Companies are well aware that a large majority of consumers would stop buying a product if they learned the company has irresponsible business practices; and know that sustainable and social policy is an important buying factor for consumers. Before, they were selling a product, with obscure working conditions, blurred origins of the raw materials, and a price no one can really understand. However, today, consumers ask for information on the product, origins of the material, environmental impact, and so on: they are looking for every element that can justify the price. And in this case, engagement and CSR are a tremendous opportunity and a necessity to deserve consumer to buy your product.

First, from a business perspective, companies play the transparency card. Becoming clear about the product, the supply chain, the working conditions, the commitment for environment, or the involvement in some charities, companies create a better brand image and completely change the perception of the brand from a simple goods provider to an engaged actor with values. They do not need to change to be more competitive and attract new consumers, but really because people are now asking for it. Moreover, from

a global perspective, CSR is a crucial point for sustainability. Finding different ways to imagine, create, and produce become necessary to assure a sustainable business.

However, when there is a business opportunity for some brands to distinguish themselves, there is also an occasion for other to play the stowaway. CSR is now the target of communication and advertising based on nothing and with one purpose: restore a tarnished image. This is greenwashing: using PR, advertising, or marketing to promote the idea of an eco-friendly company. For that, we can observe different strategies that can really change the perception of a brand.

First, you can work on the "direct image" of your product or your company. If you change your packaging or logo for something in green color or if in advertising you associate the product with images directly linked with nature, your company will look closer to the environment and well-being. Another technique is the choice of names: derivatives of "green," "pure," "nature" as name of brand, product, or collection are directly associated with an eco-friendly demarche, only with the name. In addition, if you can label the product; even with a label you have just created, with no official NGO or organization to approve, the perception of your brand will definitely change.

Nevertheless, the most used technique is the spotlighting. You take something real, turning the spotlight on, and use it as a powerful canal for your responsible communication. For instance, many European cosmetic brands claimed that their products are not testing on animals, while this practice has been banned in European Union. But companies also decide to show off projects they launch or support to make the public forget other practices.

The Body Shop is a good example of a spotlight strategy of greenwashing. Founded in 1976 by Anita Roddick, The Body Shop was one of the first companies to take position against animal testing and to claim for fair trade, more respectful of the environment. The company is presented as an advocate for environment, using natural ingredients in their products or struggle for a fair economic model. Involved in many social causes and supporting the development of different communities around the world, this company seems to be the model student. However, the reality is a little different. First, the brand is only focused on the ingredients, while containers are still in plastic and glass, which are very polluting to manufacture. In addition, even the ingredients side is far from natural. Like most of the cosmetics company, the brand uses nonrenewable petrochemicals or synthetic colors and fragrances. Moreover, in 2014, the Australian consumer advocacy group "Choice" revealed that some The Body Shop's products were available in duty-free shops in Beijing and Shanghai airports, that is to say mainland China. Yet in China, the government can randomly take cosmetics in a boutique and conduct animal testing. Therefore, the cruelty-free value of the brand was not guaranteed anymore.

Thereby, the whole communication is focused on the "green" side of the product and the projects and charities the company is involved in. The Body Shop has even created a program named Enrich Not Exploit, which fixes some objectives for 2020 to intensify its sustainable policy.

6.3.2 Influence and resonance in the globalize world

Even if there is real CSR policy, how can we explain this important leverage of eco-fashion? In the era of digital marketing and social media, the impact of influencers is more than ever a crucial parameter. Leonardo DiCaprio for the global warming, Matt Damon for the water crisis, Natalie Portman for the fossil fuels: these are just a few examples of the many key opinion leaders (KOLs) that are going into action to change the economic and social world we are living in. People trust them, agree with these causes, understanding the necessity of a different organization on a global scale, and above all ask for it. Today, 75% of the consumers say they use social media as part of their buying process: influencers have a powerful resonance in the opinion and they really participate in the mind changing.

In addition, fashion industry is not outdone in this field. Many brands already see both the potential and the urgency of changing their model. When actress Emma Watson is walking down a red carpet with a Calvin Klein 100% sustainable dress, made of recycled plastic bottles, organic cotton, and organic silk, she sent a powerful message to people and again push brands to review their model and their position about sustainability. Singer and producer Pharrell Williams, now coowner of the brand, launched an entire collection with G-Star RAW called "Raw for the Oceans." It is presented as the most sustainable jeans collection, crafted from recycled ocean plastic. The American celebrity and also one of the channel faces is involved in many causes and with his notoriety can raise awareness among these issues and encourage the public to come together.

All these elements are more than ever in the scope of companies' marketing and business strategies; they cannot ignore them anymore and have now other choices than definitively revamp their model.

6.3.3 Can we expect the current economic model to spontaneously become circular?

The conceptualization of Porter still represents today, and even 20 years later, the predominant take-make-dispose economic model, based on the use of inputs deriving from resources considered traditionally available in unlimited quantities, also due to their cost-effectiveness. However, in recent years there has been an unprecedented growth in the demand for these resources, whose procurement turned out to be instead subject to significant limits. This has challenged for the first time the current economic system, based on a linear approach. The concept of the circular economy began to develop in response to the crisis of the traditional model, due to the need to deal with the limited resources used.

The abundance of resources, so far, has allowed the affirmation of the model based on linearity, as shown in Fig. 6.1.

Figure 6.1 Model of linear economy.

Today, however, there are many critical elements, fueled by various global trends, which are questioning the ineluctability of the current linear system. Approximately, 3 billion new consumers are expected (within the middle class) by 2030, which will push the demand for goods and services to ever-recorded levels. Keeping the model of linear exploitation of resources, according to a "business as usual" logic, would mean confronting ever-increasing price volatility and a probable inflation of fundamental commodity assets and, in particular, of raw materials and natural resources.

In light of these trends, many companies are starting to insure themselves against these risks, and at the same time, they move toward changing the industrial model, in order to make growth and profits less dependent on those resources that are becoming increasingly scarce. Concurrently, policymakers are increasingly looking for a paradigm shift, aiming to transform the linearity of production systems into circularity.

The circular economy is an economy designed to "self-regenerate." The materials of biological origin are destined to fall within the biosphere, and the materials of technical origin are designed to circulate within a flow that foresees the least loss of quality. It is also an economy that intentionally "reconstitutes," aiming to rely on renewable energy sources to minimize, track, and eliminate the use of toxic chemicals and to eliminate waste and waste production, through careful design.

Mainly developed with the work of the Ellen MacArthur Foundation, the circular economy concept is based on different principles:

- Extend the life of material: As we explained, consumption society is driven by the "buy—use—throw" rule. Updated versions of every product are launched in a very short term to push people to consume and buy more and more.
- Use the waste as a material: Business models are organized around the transformation of raw material. Elements are extracted, transformed, and each product comes from unused resources. The circular economy claims for a different approach of recycling the materials, from design to manufacturing. This is an opportunity to implement a less expensive productive chain and to guarantee a high value for products.
- Use renewable energy: This is the most obvious measures companies can take. It is indeed the first step for an eco-friendly model, totally in line with the circular economy. Use, for instance, more electric machines in your factories.
- Press the lemon as much as possible before throwing it. Before declaring that an input is unusable, make sure that you use its full potential. The lemon skin can become a wonderful compost for your garden.
- Think in terms of system. A single eco-friendly initiative cannot be fully effective if you do it alone. You have to review every part of the channel and invest in a total different organization.

All these elements participate in a total different organization of our economic and business model.

6.3.4 Considering the circular economy

The ideal model of the circular economy does not, however, reflect the current reality of the production, consumption, and, above all, recovery and exploitation of waste: the

current situation is still far from the "closure of the cycle," or the possibility of reusing, recovering, or recycling all that would be discarded (Fig. 6.2).

Furthermore, the circularity of the economy not only implies the ability to reuse, recover, or recycle the waste materials that constitute the leakages during the different phases, happening in all those points in the circle where there is a loss of efficiency through the exit from the production system or consumption of potentially useful and exploitable material but also the possibility of preventing such leakages, for example, by reducing the flow and quantities of raw materials and natural resources entering the economic systems.

In other words, it would be used to reduce, the amount of the incoming flow (the raw materials arrow) to increase the system's ability to recover a greater percentage of waste. For example, the market for secondary raw materials in plastic polymers: the demand for these materials is increasing but does not reach quantitative levels commensurate with the waste plastic materials coming out of ordinary flows.

This last point underlines the complexity of the circular economy. As we said, we have to think in terms of system, not only in recycling but also in changing the whole process. It starts with the design of the product, including durable material, make it easy to fix or to reuse, and of course implies less material or energy in the manufacturing process. An eco-friendly design is possible and will produce a chain reaction on the model. The manufacturing process and the supply chain will change with different materials, different organizations, different machines, different packaging, and so on.

6.4 A world already on the move

6.4.1 Fashion in the future

The fashion industry is now facing the biggest challenge of all times: how to keep creating fashion, for a constantly growing population, without further damaging the

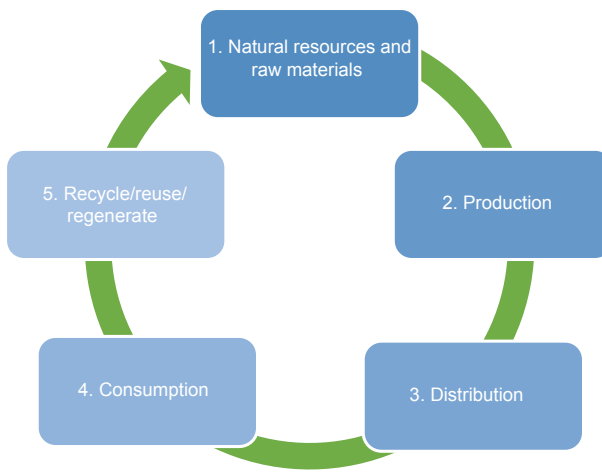

Figure 6.2 Ideal model of circular economy.

planet? What concrete steps should be modified in the creation of fashion, the proper disposal of its products, and, furthermore, in the corporate thinking?

Fig. 6.3 shows a constantly increasing interest in the matter of sustainable fashion and, in a broader spectrum, sustainable brands. Brands today are now required to have a sustainable management and image to properly follow the changes in today's needs and customer requirements. We can see on the analysis that the term "sustainable fashion" has been strongly increasing over the past decade and, even more, over the last 2 years. The industry has to face a growing requirement from the customers, and the following suggestions are an answer to it.

From a lateral reflection, the first step would be designing a new type of fabric that would consider the possible recycling process later on. That way, making a fabric that is designed to be easily sorted and recycled would save precious resources and time for the whole industry and, perhaps, become an even bigger money saver through the dispense of incineration or landfilling (the latter almost reaching their maximum capacity).

6.4.1.1 *Preconsumer*

Between the harvest and the manufacturing of cotton garments and textiles, up to 40% of raw materials are wasted into landfills or incinerators. Reusing the preconsumer production waste would save the use of production time, labor, water, and polluting chemicals and therefore contributes to a greater financial opportunity by reducing the overall costs. Reference can be made to US patent 9,133,570B2, titled "Processes for using

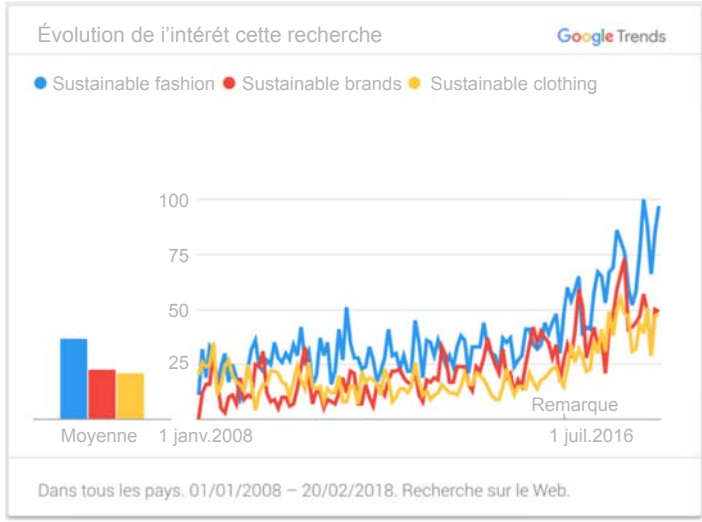

Figure 6.3 Evolution of the search interest for sustainability in fashion.
Source: From www.google.com/trends ©2017 Google LLC, used with permission.

recycled waste cotton materials in producing a textile product" (Lightman, 2015). This invention provides the means to enable the creation of first-quality finished garments from preconsumer waste, dyed and finished following any specification. Depending on the various physical properties, wasted fabrics are sorted in order to provide the best strength and appearance for each recycled fabric or garment. Further reference can be made to patent WO 2017/072718 Al, titled "Method to produce a dye for fabrics from textile waste material" (Andrea, 2016). The reuse of recycled garments and fabrics in the manufacturing of new dyes is a further step in the concept of 100% recycled clothing. Not only will the product be created from production solid waste as seen above, which is one of the biggest issues in the clothing industry, but also the dyes will be made with already-used dyes and, therefore, prevent our using of harming and polluting chemicals in the production process.

6.4.1.2 Postconsumer

Another suggestion is to properly recycle the fabrics out of used clothes, different from the reuse only. More and more fashion clothing brands now offer collecting tanks to reuse old clothes, no matter the condition, which is for most consumers the easiest way of recycling textiles along with donating to charity (Salvation Army, etc.) or reselling. Unfortunately, reusing existing garments is, according to the United States Environmental Protection Agency, not classified as "recycling" because the garments will eventually reenter the waste stream later on. Therefore, they are considered a "diversion" rather than recycling. Reusing old garments raises the issue of our inability to change their designs and, more importantly, their colors without further damaging the environment (bleaching old garments would generate an important amount of wastewater). Furthermore, if the clothes arrive wet or soiled, it is impossible to reuse them as washing and drying facilities are not present at sorting units; unusable garments are then landfilled or disposed. Further reference may be made to patent WO 2011/077446 Al, titled "Process for recycling cotton fabrics" (Gambhir, 2011). This invention relates to adapting recycled cotton paper yarn fabric to overcome the above challenges and reusing waste garments in the required color, construction, and design. The rags are collected and recycled in an inventive process so as to make recycled cotton products having quality and appearance as per the today's market standards.

Using the scraps from agriculture or food waste into the processing of yarn could help address both issues, as they are estimated to generate 15 to 25 million tons of solid waste per year (Marín et al., 2007). The most abundant source of scraps is citrus, accounting for 50% of the whole fruit solid waste (Cohn and Cohn, 1997) and therefore constituting a severe environmental problem (Laufenberg, Kunz and Nystroem, 2003; Montgomery, 2004). Therefore, solid waste could be a thing of the past, while more attention could be given to the issue of wastewater. The main cause of wastewater is the use of toxic chemicals during the dyeing process. Water-free and chemical-free dyeing should become a worldwide standard, such as the air-dyeing technology which is believed to use 95% less water, require 87% less energy, emit 84% less greenhouse gases, and allow for new designs (Kant, 2012).

6.4.2 From process to concrete elements

No matter the line of business, each company has the responsibility of reducing its carbon footprint and that goes, firstly, through the building and development of green facilities, e.g., offices, factories, retail stores, etc.

Circular economy in fashion is not only a matter of reducing the ecological impact of the products but also the way the whole company is ran. A green building takes efforts in each step of its conception, e.g., how it is designed, constructed, operated, etc.

First, the building must be designed to efficiently allocate heat and cold to save energy and prevent the waste that is common to most corporate buildings, the way the building is oriented, where it is, how exposed to the sun it is, etc. Nature is not only an unlimited source of energy that could be used in this purpose but also we could need it for further purposes: green buildings should have a sufficient share of their energy through solar power or wind power. In addition, its orientation could minimize the use of artificial lighting and, therefore, save even more energy.

We mentioned earlier the preciosity and scarcity of water, and the impact of the fashion industry in its situation. Point of use water treatment and heating are ways to improve both water quality and energy efficiency while reducing the amount of water in circulation (Ragheb et al., 2016). Furthermore, the use of natural, local, and nontoxic materials in the building foundations (for instance locally obtained, responsibly harvested wood and stone) is a way to provide a sustainable supply not only in the shorter transportation but also in the way of helping local companies. Adapting or reusing older buildings is also a way to provide a new sustainable working habitat without generating further waste and saving construction costs.

Another key element for a sustainable design is durability. How come, buildings as the Pantheon in Rome or the Maison Carrée in Nîmes have been able to live for over 2000 years? One of the next challenges is to develop materials to build durable constructions. Buildings could then last centuries with only minimal maintenance, before being used for other purposes.

Moreover, all buildings to be constructed should now comply with the regulations of certifications such as the Leadership in Energy and Environmental Design (LEED). LEED certification rates the Before−During−After of new buildings: from the design and construction to operation and maintenance, every step is rated to make sure the building is sustainable, uses resources as efficiently as possible, and remains environmentally responsible. It was developed by the nonprofit US Green Building Council (USGBC) 25 years ago and has been applied to more than 80,000 projects worldwide.

There are actually four levels of LEED certification:

- Certified (0−49 points)
- Silver (50−59 points)
- Gold (60−79 points)
- Platinum (80 points and above)

There is a total of 100 possible base points, distributed on six different categories:

- Sustainable sites

- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation and design

As of October 2017, some 65,427 projects LEED (Cumulative number of LEED, 2018) were registered. This shows the growing interest in designing sustainable and responsible buildings. However, not all of them show significant results regarding water and energy saving performance.

Indeed, in a study of 953 New York City office buildings in 2013, 21 of them were LEED certified. The LEED certified buildings were compared with noncertified buildings of the same type, with the exact same geographical and climate region, as all were located in New York. LEED Silver and LEED Certified underperformed compared with the other office buildings, whereas the more demanding and sustainable LEED Gold buildings were outperforming other offices by 20% on energy savings (Scofield, 2013). Therefore, it is crucial for companies to succeed in the Gold level of this certification for significant results and impacts on the environment.

Regulations such as LEED should be more than just a criterion, but a mandatory standard for all the fashion industry. Indeed, it regulates not only the materials and resources used to construct but also how it will be managed through time. Water, energy, and atmosphere efficiency as well as innovations in operations and regional priority are the key topics answered by this regulation. Should all buildings follow this certification, fewer and fewer constructions should be needed, as they will comply with the best sustainable criteria. Therefore, should a company leave its office, another could take its place without further operations.

Even the packaging can be more sustainable and participate in a circular model. Companies in the luxury fragrance industry are always innovating to find new shapes and functionalities for their products.

More and more consumers are concerned about how sustainable the packaging of products is. One way to reduce the ecological footprint in terms of packaging would be to have refillable options available. In 2014, Beauty Retail Trends stated that refillable packaging was an emerging option for high-end retailers. The refillable functionality could mean having, for example, a soda stream-like dispensary for high-performing perfumes. Another idea could be to use biodegradable packaging to send refills to customers thereby repurposing old bottles and preventing the creation of a new one. Partnering with companies that produces recyclable, biodegradable, and compostable bottles would greatly reduce the ecological footprint of key players in the perfume industry.

At the very least, companies should be supporting the postpurchase life cycle of the product. In 2009, Kiehl's, a subsidiary of L'Oréal, introduced a recycle and a rewarded program where people could return their used bottles and get stamps. For each 10 stamps a free travel-sized product up to $11 in value is earned. All of the collective bottles are shipped to TerraCycle where they are recycled into new product. In 5 years

Kiehl's recycled more than 1.3 million bottles diverting more than 2.5 billion pieces of trash from heading to the landfill (Greener Package, 2014).

Last but not least, a large part of the environmental impact of the perfume industry comes from emissions caused by the transport of raw materials from harvest to extraction. The transport of raw materials across the world not only consumes a lot of resources but it also creates significant pollution. Large quantities of raw materials are required to extract the essence used in perfume. For example, it takes 10,000 kg of rose petals just to produce 1 kg of rose essence. After the materials have been harvested the essence needs to be extracted, through a series of processes that take place either on site or at the perfumery.

This is how innovation should be used to promote another manufacturing process in a more sustainable objective. One idea is to use the process of extracting by supercritical fluids that would simplify the number of steps in the process chain for solvent extraction. This method reduces costs, reduces energy use, and does not involve toxic solvents. Another innovation is to make the extraction process transportable. For instance, lavender can be harvested and immediately cut and put into a mobile kettle placed above a boiler. Then the lavender can be distilled on the spot thereby reducing the handling time and simplifying the process as a whole. Instead of shipping the raw material thousands of kilometers across the world, they can be processed with mobile equipment. To sum up, "green" distillation and simplifying the number of steps in the extraction process can be cost-effective and significantly reduce the ecological footprint and the carbon cost associated with producing the product.

6.5 What next?

6.5.1 Economic system supported by green finance

Considering the massive change our world is going to face, it is worth noticing to analyze how this impact on our model is financed. Of course, a drastic and complete revolution in processes, in manufacturing, in distribution, or in design has a cost and here comes into play in the financial market.

These dematerialized markets are on every lip and every speech since the 2008 financial crisis. Then came the debt crisis in many European countries, the Chinese stock market crisis and the tax haven scandals. Most people do not know exactly how financial markets work, but everybody can understand their crucial important to realize project. The ongoing trend for sustainability also has gained the financial world with the green finance.

Green finance is the financing allowance for investments that take into account the environmental and social issues to promote a sustainable growth. Nannette Lindenberg, economist and researcher in the Department of World Economy and Development Financing at the German Development Institute, specialized in green finance, proposes a complete definition to embrace the whole concept. For her, green finance comprises the following:

- The financing of public and private green investments:
  - Environmental goods and services (water management, protection of biodiversity, landscapes, etc.)
  - Prevention, minimization, and compensation of damages to the environment and to the climate
- The financing of public policies encouraging environmental projects and initiatives
- Components of the financial system that deal specifically with green investments (Green Climate Fund or financial instruments for green investments such as green bonds and structured green funds)

In 2016, the climate-aligned bond market reached $694 billion, with only 17% labeled green bonds. The rising of these investments is in fact an interesting signal of the global changes that occurred today. Financial markets can take part of the substantiality objective implement by the society and participate in creating a complete eco-system of financial products private individuals can buy, and in this way be an actor of sustainable economy at a small scale.

6.5.2 Back to the future

The business world is already on the move and many things have changed since the awareness of the public and the time of scandals. Some companies have perfectly integrated the CSR policy and the necessity of finding a new model at the center of concerns.

Nike is a perfect example of sustainability evolution. In 1996, images of a young boy in Pakistan, warned the public about Nike's working conditions. The next year, a report made by Ernest & Young revealed that 77% of workers at the supplier's factory had respiratory problem. Even if Nike claimed to have no control on the suppliers, the damage has been done: Nike's revenue dropped from $9.6 billion in 1998 to $8.8 billion in 1999. It was time for Nike to revamp its image.

The next year Nike embraces UN universal principles on environmental practices and human and labor rights to finally publish a full CRS report and create a board-level committee for corporate responsibility. Transparency was the only way for Nike to make the public forget about the scandals. In this way, they publicly published the full list of their suppliers and factories around the world in 2006. In addition, the company is now a leader in terms of sustainability, not to avoid the scandal to break again, but because sustainability is a real business opportunity. Now Nike has its own Sustainability Business and Innovation (SB&I) department, with the "SB&I lab" focused on innovation. Finally yet importantly, the company launched a smartphone application in 2013, to *help designers and product creators make informed decisions about the environmental impacts of the materials they choose*. You select the material and the application gives you the environmental impact by telling you if it is a recyclable material, how much water you need to transform it, what amount of chemical product, etc. This example is not just a good communication story, it is the perfect example of what a company can do to change its entire organization and to work toward a "zero waste" goal.

However, mass market is not the only industry that can perform in sustainability or need this asset to win people sympathy.

"I design clothes that are meant to last. I believe in creating pieces that are not going to get burnt, that are not going to landfills and that are not going to damage the environment. For every piece in every collection, I am always asking what we have done to make this garment more sustainable and what else can we do. It is a constant effort to improve."—Stella McCartney. The British designer claimed to be one of the very first luxury brand organized on a circular model for a sustainable activity. In fact, we can read this chapter again and see that every element can be illustrated by Stella McCartney company. When she launched her business in 2001, she wanted to show everyone that a sustainable and eco-responsible fashion creation and production is possible.

Harvard Business School professor Anat Keinan, who published a case study on the brand, reminded that luxury and sustainability, contrary to what one may think, reflect same values. One of the characteristics of a luxury brand is to be the best, with the best behavior, the best image, the best products, the best creation value, and so on. In addition, today, luxury brands should embrace CSR as a new field for them to be the best: they have to show involvement and commitment in sustainability and eco-friendly attitudes.

This is what Stella McCartney stands for: responsible action and sustainable methods. Concerning the products themselves, the brand is way ahead of other players. She is not using fur or leather and try to use as much as possible organic cotton. Every product is designed thinking about how people will use its full potential and also how the brand will recycle it (people throw away 90% of what they are going to buy in the next 2 years). For instance, cotton is a water-intensive crop and, also one of the most toxic. In 2016, 60% of all the cotton (its most used material) used by the brand came from organic farming. Cotton farming uses around 2.5% of global cultivable land, with the use of 24% of insecticides and 11% of pesticides. On the other hand, organic cotton requires much less water from local water sources, using natural inputs only.

In addition, every line of product is a concern: from the bag made with polyester and recycled plastic bottles to the sunglasses made at 50% with natural materials. But the initiative is much wider than just products. Every location is equipped with a recycling system to make sure customer can participate in closing the model's circle. The company's buildings from offices to stores are also respecting the environment. Forty-five percent of the company activity is reliable only on 100% renewable energy. In the United Kingdom, buildings are supplied by green electricity produced by wind power.

Why Stella McCartney performed in this eco-fashion field? Simply because she acts like a normal person, or at least does not act like a profit-driven CEO. Looking at her social media strategy, we noticed that her company and her personal account on Instagram are the same and only one account. She acts like a social influencer, a KOL as we described them before. Her implication for real changes like with the Natural Resources Defense Council (NRDC) in America, the Ellen MacArthur Foundation, or her R&D initiatives for new textiles and are proof of her sincerity, and people trust her for that. They trust her, and they want to participate in her project and the brand has now the strongest image for sustainability in the luxury fashion industry.

Moreover, this image embodied by Stella McCartney herself, is a powerful leverage used by other brands. When she created capsule collections with brands such as Adidas, H&M, or L'Oréal, she spread the good practices in the mass-market industry.

From a consumer point of view, the digital sphere has seen numerous initiatives, which participate in the circular economic model. Moreover, the fashion trend for vintage clothes has been a wonderful opportunity to develop these initiatives. For instance, platforms such as *Swap*, *The Real Real*, or *Vestiaire Collective* are well-known online places where you can sell or buy your personal fashion items. To have a clear idea of the phenomenon, a Deloitte study estimates the market of sales between individuals at a global scale at 100 billion dollars for 2018. In this way, the whole chain participates in this transformation of the economic system. Even the consumers are now actors of the change with their act of purchase. They can decide to buy a product designed for a long-lasting existence, which respect the process and engagement we describe before, or they can buy on the second-hand market and make sure that a product is used as long as possible, before been recycled and be part of the chain again.

6.5.3 Grow your own clothes

When life gives you lemons …

A further speculation on the fashion industry's next decade could be the use of nature as a tool and a source of inspiration in the designing and production phases.

For 6000 years, indigo and cotton have been paired—and not only for blue jeans. This organic compound, named as its singular blue color, was extracted originally from plants in the genus *Indigofera* (over 750 species), widely found in the tropical and subtropical regions of the world. The leaves, once marinated in water and fermented, generate a strong dye in the color we know. Carmine, another natural dye (bright-red color) derived from the cochineal (a tropical parasite), has been used for centuries by the Mayans and the Aztec. They collected these insects on cactus and grinded them; the carminic acid found inside them gives this red color that can be then used as a dye. Those two natural dyes are still used today, and both come from nature; yet another source of dyes has not been much exploited—bacteria—and more precisely, actinobacteria. One designer, however, Natsai Audrey Chieza, has started to use one of those bacteria, the *Streptomyces coelicolor*. The fabrics are soaked in a culture of these bacteria and, once incubated, the bacteria will generate an uneven pigmentation on the garment. The colonies will create an original, unique pattern with a gradient of colors that cannot be imagined. Letting nature decide of the color of your garment is a quite different way to design clothes and, perhaps, it is a way to produce beautiful and unexpected outcomes. This means of dyeing is not much developed yet, but it can already save a lot of water, to dye one tee shirt, only 200 mL of water are needed.

On top of requiring the lives of millions of animals every year, the animal leather production also needs incredible amounts of water, dyes for tanning, toxic treatments, and so on. With a growing interest in sustainable leather goods in the fashion industry, a new concept is also generating more and more attention: vegetal leather. Two recent

companies have found unlimited resources: Myco Works and Vegea. The first one uses mycelium, the vegetative tissue of mushrooms, to make a water-resistant, cost-effective, and versatile leather. Using mushrooms makes actually the most absolute example of circular and sustainable economy, as their leather is 100% biodegradable, which, therefore, makes it an infinitely renewable technology. The second makes leather out of the wastes from the winemaking industry in Italy and has been granted 300,000$ in 2017 by the Global Change Award (H&M Foundation).

A further way to innovate in the fashion industry is biomimicry. It consists in finding inspiration in the ways of nature, and it is already used widely in architecture and design. An American company called Bolt Threads has engineered a yeast to produce a spider silk protein that can be used and spun into a highly programmable yarn. Through fermentation, their protein can be produced in very large quantities and it can be tuned to fit whatever need it is supposed to answer: stretch, super-strength, comfort, water-resistance, softness, or even its weight. Their yarn is therefore 100% customizable and can replace other fabrics with the same properties but a way bigger need in water and chemical treatments. Customization is a key to the fashion industry's future, and it is a way to provide an answer to every need; therefore, the more it has used, the fewer waste will be generated from the other means of producing fabrics. Grown textiles will help reduce not only the amount of water needed to grow cotton but also the use of coal or gas that are required to produce synthetic fabric. Depending on the type of synthetic fabric, toxic materials are used to make it stronger, softer, or resistant to fire and water. Unfortunately, even though their characteristics are quite interesting, synthetic fabrics also generate a waste that will take hundreds of years to disappear. Preventing the use of those chemicals could help further the cause of circular economy in the fashion industry and focus on materials that are biodegradable and that do not hurt the environment as well as all the living things on our planet.

Furthermore, the remaining wastewater from the growing of cotton as well as the dyeing of all fabrics requires an additional attention. This water should serve a new purpose, and either be filtered following the same regulations for all countries producing fabrics to provide a healthy, drinkable water, or it should serve other purposes. Each milliliter used to produce and grow should be recycled and, what cannot be filtered because of too much chemicals, should be used again and transformed as a biogas for instance.

Following all those steps could provide a fully recyclable and circular fashion industry: every bit of waste will be reused into something else, garments will have an unlimited life (and not in landfills), and the planet will benefit from all the gains in water with the billions of people that are about to be born.

6.5.4 Food for thought

All the elements, such as clothes, textile, fashion, perfume industry, architecture, packaging, marketing, etc., now become more sustainable, transformed to be part of a new economic system. An economic system based on eco-friendly practices, to reduce the impact on the environment and produce to last. First thing first, the coherence should be to start with the ground and with the food culture and production we do.

Circular economy comes from the wish of preventing human kind from destroying the planet. And that exactly why the food consumption, like the water utilization, should be taken into account in the whole evolution channel of our economic and social system. Why is the purpose of avoiding polluting with textile or buildings, if you waste tons of food or use pesticides?

The circular economic food system is mainly based on three points we already discussed in the beginning:

- The use and management of resources: Producing food mainly depending on environment. Consequently, the protection of the soil, the water, or the biodiversity is not only sustainable but also necessary to provide food for everyone. Moreover, these elements can be used differently and be the starting point for innovation and creation of renewables.
- The notorious problem of food waste: It is now obvious for everyone that standards and policies around the world are the causes of a huge food wasting. Now more than ever, we have to be careful about the allocation of food around the world. Studies show that if we continue to consume food like this, we will not be able to have enough protein for everyone in 2050. Therefore, we do have to also change your diet: more vegetable protein and less animal protein, a very resource-intensive production.
- The optimum use of elements: The basic concept of circular economy. Food waste and residues can be used for many other things, rather than be burn polluting the air. The natural waste can produce compost and be part of the chain again.

Thereby, the way we consume is very important and have a direct impact on the environment we live in. The model of circular economy is very complete, and it can be adapted from food production to textile manufacturing or building construction. This evolution is a wonderful business opportunity, for innovation, design, processes, and even marketing. This is, without doubt, the next step of our global economic organization.

6.5.5 A circle for life?

Decrypting and explaining every aspect of the circular economy, why our society really needs to evolve to a new model, how this approach can be developed and implemented in different industry, notably, the textile industry, we can ask ourselves does the circular economy the final step of a sustainable economy?

Different studies and specialists in economy argue that there is more to accomplish in terms of sustainability. The circular economy, even if it is based on a zero-waste demarche, with recycling and so on, the finality is to produce something. Other solutions are possible and should be noticed. This is the sharing economy or the "crowd-based economy" as Arun Sundararajan, professor at the New York University, names it.

The fast-growing digitalization is the central point of this economy. As the executive director of the Earth Institute, Steve Cohen explained, "Young people are valuing experiences over ownership." Now is not a reflection about how I can acquire something, but how can I find this think for a precise or limited use.

Young generations are now growing in the world of platforms, where every traditional aspect of businesses is reevaluated: the online existence instead of the physical one challenges the way we organized employees, supply chain, consumers, but even

the question of a hierarchy. The path started with the Internet, which gathered and liked people around the world; it was a tremendous platform for traditional businesses, with the opening of new markets, new technologies, innovations, and so on. Now we see that the global community formed online is closer than ever. Close to the point that now, users are willing to share what they have and to help one another.

Now we see completely different models and the "traditional" economic world cannot keep up with these changes: Airbnb the famous "hotel" company does not have any proprieties, and Lyft the most famous "taxi" company does not own any car. These are typical examples of what a company design on the sharing economy model looks like. So, what are the main characteristics of this economic system? Arun Sundararajan distinguished five main elements:

- Largely market-based: Digital sphere enables the extension of the market and consequently the number of possibilities (more exchanges, new services, new interactions, etc.)
- High-impact capital: The system allows to use the full potential of every types of inputs through new opportunities
- Crowd-based "networks" rather than centralized institutions or "hierarchies": Everything comes from the base not from corporate or centralized third parts.
- Blurring lines between the personal and the professional: As people help one another, we do not know exactly where the commercial relationship starts.
- Blurring lines between fully employed and casual labor, between independent and dependent employment, between work and leisure: The traditional subordinated work relationship faced entrepreneurship, contract work, etc.

This theory of a global sharing economy is just one more sign that suggests our world is going to change and evolve. It would be a terrible mistake to think that the current capitalism system, as we know, is the final and ultimate stage of the economic evolution.

The full potential of the circular economy is a tremendous opportunity for many businesses to create a sustainable value. But once again, we have to think about it as a step. One more step toward something different, a revolution of our vision of production and consumption: a brand-new world will show up with lot of opportunities.

6.6 Conclusion

We explained how our society exploited the linear economic model to its maximum until the scarcity or resources and the evolution of the society. Different parameters push many industries to change tactics and embrace a different development mode. In that perspective, the circular economy is a complete organizational revolution that leads to a new system based on an optimum utilization of resources. Processes are adapted and the whole chain is modified in a sustainable purpose. In addition to this the economic model change can be followed by various initiatives already set in many industries and supported by finance, design, or research and development.

With this turning point of our global standardized economic system, there is a question of justice and equality toward the ability of implementing such a system. Does this

necessary revolution of the economic system, look as another stone on the wall dividing developed and developing countries? The impact of the circular economy on the environment will be very efficient only if the major actors in terms of manufacturing are willing and able to change their organization.

References

Andrea, V., 2016. Method to produce a dye for fabrics starting from textile waste material, and method to dye fabrics. International Publication Number WO 2017/072718 Al, International Application Number PCT/IB2016/056514.

Association SMaRT, 2011. Donate, Recycle, Don't Throw Away. https://www.smartasn.org/SMARTASN/assets/File/resources/SMARTInfographTextileRecycling.pdf.

Climate Bonds Initiative, 2016. Bonds and Climate Change The state of the market in 2016. Bonds and Climate Change. [online] Climate Bond Initiative. Available at: https://www.climatebonds.net/files/files/CBI%20State%20of%20the%20Market%202016%20A4.pdf [Accessed 7 Sep. 2018].

Gambhir, V., 2011. Process for recycling cotton fabrics. International Publication Number: WO 2011/077446 A1. International Application Number PCT/IN2010/000793.

Cumulative Number of LEED Registrations in the U.S. From 2000 to 2017, 2018. https://www.statista.com/statistics/323383/leed-registered-projects-in-the-united-states.

Eco Tlc, 2016. 2016 at a Glance - Half-way Results from the 2014−2019 Accreditation Agreement. http://www.ecotlc.fr/ressources/Documents_site/2016_at_a_glance_BD.pdf.

Cohn, R., Cohn, A.L., 1997. Subproductos del procesado de las frutas. In: Procesado de frutas, (Ed.) D. Arthey and P.R. Ashurst. The Integrated Management of Food Processing Waste: The Use of the Full Cost Method for Planning and Pricing Mediterranean Citrus By-Products. Available from: https://www.researchgate.net/publication/282320447_The_Integrated_Management_of_Food_Processing_Waste_The_Use_of_the_Full_Cost_Method_for_Planning_and_Pricing_Mediterranean_Citrus_By-Products [Accessed Sep 07 2018].

Gordon, S., Hsieh, Y., 2007. Cotton. Woodhead, Cambridge.

Greener Package, 2014. Kiehl's collects 1.3 million containers for upcycling | Greener Package. In: Greenerpackage.com. https://www.greenerpackage.com/recycling/kiehls_collects_13_million_containers_upcycling. [Accessed 7 Sep. 2018].

Kant, R., 2012. Textile dyeing industry an environmental hazard. Natural Science 04, 22−26. https://doi.org/10.4236/ns.2012.41004.

Laufenberg, G., Kunz, B., Nystroem, M., 2003. Transformation of vegetable waste into value added products: (A) the upgrading concept; (B) practical implementations. Bioresour Technol. 87, 167−198.

Lightman, E.D., September 15, 2015. Processes for Using Recycle Waste Cotton Material in Producing a Textile Product and Textile Products Produced from Waste Cotton Material. US Patent 9,133,570 B2.

Lyons R. Valuing Our Clothes: The Cost of UK Fashion 2017 http://www.wrap.org.uk/sustainable-textiles/valuing-our-clothes.

Marín, F., Soler-Rivas, C., Benavente-García, O., et al., 2007. By-products from different citrus processes as a source of customized functional fibres. Food Chemistry 100, 736−741. https://doi.org/10.1016/j.foodchem.2005.04.040.

Montgomery, R., 2004. Development of biobased products. Bioresour Technol. 91, 1−29.

Pensupa, N., Leu, S., Hu, Y., Du, C., Liu, H., Jing, H., Wang, H., Lin, C., 2017. Recent trends in sustainable textile waste recycling methods: current situation and future prospects. Topics in Current Chemistry. https://doi.org/10.1007/s41061-017-0165-0.

Ragheb, A., El-Shimy, H., Ragheb, G., 2016. Green Architecture: A Concept of Sustainability. Procedia - Social and Behavioral Sciences 216, 778–787. https://doi.org/10.1016/j.sbspro.2015.12.075.

Scofield, J., 2013. Efficacy of LEED-certification in reducing energy consumption and greenhouse gas emission for large New York City office buildings. Energy and Buildings 67, 517–524. https://doi.org/10.1016/j.enbuild.2013.08.032.

Vulser, N., 2018. Perfume manufacturers must cope with the scarcity of precious supplies. In: The Guardian. https://www.theguardian.com/business/2014/mar/04/chanel-perfume-legislation-guerlain-loreal.

Waste Reduction, 2016. Monitoring of Solid Waste in Hong Kong (Waste Statistics for 2016). Environmental Protection Department. https://www.wastereduction.gov.hk/sites/default/files/msw2016.pdf.

Global Average LCIA Results for Cotton Fiber, Knit Fabric and Woven Fabric. In: Life Cycle Assessment of Cotton Fiber & Fabric Full Report, 2018. https://cottoncultivated.cottoninc.com/wp-content/uploads/2015/06/2012-LCA-Full-Report.pdf.

Stella McCartney, engaged for sustainable fashion. In: Living Circular, 2018. https://www.livingcircular.veolia.com/en/heroes/stella-mccartney-engaged-sustainable-fashion.

Further reading

Chemat, F., Vian, M., Cravotto, G., 2018. Green Extraction of Natural Products: Concept and Principles.

Cimatti, B., Campana, G., Carluccio, L., 2017. Eco design and sustainable manufacturing in fashion: a case study in the luxury personal accessories industry. Procedia Manufacturing 8, 393–400. https://doi.org/10.1016/j.promfg.2017.02.050.

Debbie Moorhouse & Danielle Moorhouse, 2017. Sustainable design: circular economy in fashion and textiles. The Design Journal (20:supp1.), S1948–S1959. https://doi.org/10.1080/14606925.2017.1352713.

Newell, A., 2015. How nike embraced CSR and went from villain to hero. In: Triple Pundit: People, Planet, Profit. https://www.triplepundit.com/special/roi-of-sustainability/how-nike-embraced-csr-and-went-from-villain-to-hero/.

Nisen, M., 2013. How nike solved its sweatshop problem. In: Business Insider France. http://www.businessinsider.fr/us/how-nike-solved-its-sweatshop-problem-2013-5.

Nisen, M., 2018. Stella McCartney Official website. Stellamccartney.com. https://www.stellamccartney.com/cloud/stellawp/uploads/2017/09/Stella-McCartney-EPL-Report-2016-FINAL.pdf.

Ross-Carre, H., 2016. L'economie circulaire. Afnor editions, La Plaine Saint-Denis.

Scofield, J., 2018a. Kiehl's Collects 1.3 Million Containers for Upcycling | Greener Package. Greenerpackage.com. https://www.greenerpackage.com/recycling/kiehls_collects_13_million_containers_upcycling.

Scofield, J., 2018b. Top 10: ecological packaging, vivid brand. In: Vivid Brand. http://vividbrand.com/views/ecological-packaging/.

Steeman, A., 2013a. Nike unveils new app to help designers invent better. In: Nike News. https://news.nike.com/news/nike-unveils-new-app-to-help-designers-invent-better.

Steeman, A., 2013b. Through the Years: Nike's History of Sustainable Innovation. In: The Guardian. https://www.theguardian.com/sustainable-business/nike-history-sustainable-innovation.

Steeman, A., 2016. Climate Bonds Initiative in Association with HSBC Climate Change Centre of Excellence. Climatebonds.net. https://www.climatebonds.net/files/files/CBI%20State%20of%20the%20Market%202016%20A4.pdf.

Steeman, A., 2018. Does a Sustainable Packaging Exist for the Fine Fragrance Industry? (Part 1). In: Best in Packaging. https://bestinpackaging.com/2010/10/06/does-a-sustainable-packaging-exist-for-the-fine-fragrance-industry-part-1/.

Sundararajan, A., 2017. The Sharing Economy. The MIT Press, Cambridge (MA).

Sustainability in the fragrance and flavour industry. In: Gone Adventurin, 2018. http://www.goneadventurin.com/fragrance-sustainability/.

Varun, G., June 30, 2011. Process for Recycling Cotton Fabrics. International Patent WO 2011/077446 A1.

Venier, A., May 4, 2017. Methods to Product a Dye for Fabrics Starting from Textile Waste Material, and Method to Dye Fabrics. International Patent WO 2017/072718/A.

Weetman, C., 2017. A Circular Economy Handbook for Business and Supply Chains. Kogan Page, New York.

Sustainable business strategies and circular economy

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7.1 Introduction

Circular economy has without a doubt winded up plainly as one of the interesting issues openly banters about new, more supportable industrial standards and strategies (Vermeulen, 2015; Xue et al., 2010). For sure, circular economy goes for changing inside and out the way we utilize assets, by supplanting existing open creation frameworks, i.e., frameworks in view of a direct utilization economy demonstrate where crude materials are extricated, handled into completed items, and end up plainly squander after they have been expended, with shut creation frameworks, i.e., new frameworks where assets are reused and kept in a circle of generation furthermore, use, permitting to produce more esteem and for a more extended period (Su et al., 2013; Geng et al., 2009). Such frameworks expect to keep items, segments, and materials at their most noteworthy utility and incentive for whatever length of time that conceivable inside specialized and organic cycles. The circular economy can in this way give numerous esteem creation instruments, decoupled from the utilization of limited assets and the age of squanders and ecological effects, thus going about as a portal toward a more reasonable and prosperous economy (Heyes et al., 2018).

The present portrayal of circular economy, i.e., the one in light of macroloops related with the item life expansion, its redistribution and reuse, remanufacturing and reusing, does not permit recognizing diverse plans of action, i.e., diverse methods of appropriation of circular economy by organizations. Indeed, even the narrative of circular economy rises up out of surviving writing commitments.

Changes are taking place worldwide in business strategy as industries face increasing pressures from economic crises, resource scarcity, and pollution. Many different approaches to sustainability have been explored for the manufacturing industry, but despite efforts to reduce their carbon footprint, a large amount of enterprises continues to operate in a take−make−dispose rationale (Dobbs et al., 2011; Allwood et al., 2011). The characteristics of a product directly influence the way the entire value chain will be constructed and managed, therefore design has a crucial role in supporting closed-loop supply chains and shared ownership models for sustainability. The circular economy, also known as a "closed-loop" economy, is an industrial and social evolutionary concept that pursues holistic sustainability goals through a culture of no waste.

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00007-8

The encircling of circular economy thinks about that, contrary to direct economy, financial performing artists would apply no net consequences for the earth. This objective is for the most part sought after by upgrading the life cycle of the "item," with the intend to have negligible info and insignificant creation of framework "squander." This includes a framework for accomplishing net decreases at the hierarchical inventory network and mechanical levels (D'Amato et al., 2017).

The circular economy expects to upgrade asset productivity and ecological execution at various levels, for instance, singular organizations, modern territories, and the city and provincial levels. The circular economy goes past ideas, for example, lessening, reusing, and reusing squanders—to amplify asset proficiency (Wen and Meng, 2014). On the other hand, the circular economy display holds onto imaginative ideas, for example, outlining out waste and seeking after eco effectiveness rather than eco-effectiveness. In this manner, circular economy thinking has the potential to persuade and bolster feasible business advancement to close, moderate, and tight asset circles. Along these lines, the progress to the circular economy infers a whole system change, through mechanical and noninnovative developments all through a whole association. Such advancements extend from item plan and mechanical make to the origination of altogether new plans of action, including the way esteem is made, caught, and conveyed to clients (Bocken et al., 2014).

The idea of the circular economy has turned out to be a standout among the latest recommendations to address ecological maintainability. This is done through tending to monetary development, while in the meantime considering the deficiency of crude materials and vitality, and in addition another developing business build (Murray et al., 2015). Circular economy depends on shutting circles' through various kinds and levels of recuperation by changing material into valuable products and enterprises through asset productivity. Asset proficiency inside circular economy is accomplished by keeping the additional incentive through the reasonable utilization of crude materials and vitality utilization through all phases of the esteem chain, and by utilizing items for as long as could be expected under the circumstances, along these lines disposing of waste (Webster, 2013; Bilitewski, 2012).

7.2 Circular economy

The roundabout economy concentrates on the best way to augment the procedures largely and secure as low ecological effect as could be expected under the circumstances. It implies asset minimization and proficient asset utilization. Items and materials are intended to be updated or recoursed and utilized again, through whatever number cycles as could reasonably be expected. It suggests deliberately outlined frameworks where items are connected to material cycles and intended for dismantling and repurposing. The idea is firmly identified with Cradle-to-Cradle, Closed Loop, Blue Economy, and other comparative ideas.

The thought of circular economy is approximately in light of a divided gathering of thoughts got from an assortment of logical controls and semi scientific ideas. In the

building field, specifically in modern environment, circular economy—related research has discovered a home as a state of takeoff.

7.2.1 Characterizations in view of the reasonable business approach

The item reuse, remanufacturing and restoration, requesting less assets and vitality are monetary too than regular reusing of materials as poor quality crude materials. The time the incentive in the assets spends/lives inside the inward circles ought to be amplified. Materials should first be recuperated for reuse, restoration furthermore, repair, at that point for remanufacturing and later for crude material usage, which has been the fundamental concentration in conventional reusing. As indicated by circular economy, burning for vitality ought to be the second to last choice while landfill transfer is the last choice (Korhonen et al., 2018). Along these lines, the item esteem chain and life cycle hold the most noteworthy conceivable esteem and quality to the extent that this would be possible and is additionally as vitality productive. Once a crude material is separated, refined, and delivered with the standard costs, it bodes well to utilize the esteem created to the extent that this would be possible, i.e., keep the item work/administration and utilize an incentive in financial flow to the extent that this would be possible.

7.2.2 Concept of circular economy

While a portion of the methodologies and models behind the circular economy talk has influenced essential commitments to supportability science previously, the hypothetical association is not unmistakable. These incorporate the points of confinement postured by thermodynamics, spatial and transient framework limits, and in addition the administration and administration challenges concerning between sectoral and interorganizational material and vitality streams. Subsequently, a moved forward definition is required. The definition that we give here is just a "develop" for what comes after, i.e., it is not expected as a general furthermore, outright definition. It needs a development. As it were, here we build up the idea in light of current learning and afterward, in the resulting segments, we utilize it for its deconstruction and recreation toward additional sensible pathways to gain ground in manageable advancement in general through circular economy work.

From the viewpoint of sustainable advancement and its three measurements, monetary, natural, and social, the crucial highlights of how the idea is characterized should incorporate on the one hand, a state of takeoff underway utilization frameworks that augment the administration created from the straight nature—society nature material and vitality throughput stream. This is finished by utilizing patterned material streams, sustainable power sources, and falling compose vitality streams in incorporated generation e utilizations frameworks, including their between sectoral, between authoritative also, worldwide esteem chains and life cycles. Then again, the fruitful appropriation of

CE has an all-encompassing commitment to all the three measurements of economic advancement. In like manner, this restrains the throughput stream to a level that nature endures and uses biological system cycles in financial cycles by regarding their regular propagation rates. More financial esteem is removed from the existing physical streams and foundations of the economy.

Circular economy is a practical advancement activity with the goal of lessening the societal generation utilization frameworks' straight material and vitality throughput streams by applying materials cycles, sustainable and course write vitality streams to the straight framework. Circular economy advances high esteem material cycles nearby more conventional reusing and creates frameworks ways to deal with the collaboration of makers, purchasers, and other societal on-screen characters in economic advancement work.

7.2.3 Global demand

The circular economy moves from the planet-sparing talk that is regularly a mood killer for advertisers and numerous representatives and businessmen and women. It expresses a reasonable, long haul business-drove issue and offers an unmistakable, long haul business-drove reply. It turns exorbitant, negative issues such as waste, into positive, esteem making assets.

7.2.4 Feasible assembling studies in circular economy

Feasible assembling studies and the circular economy in the business implies monetary, natural, and social supportability. The limits of economic maintainability are gainfulness, future aggressiveness, and financial effect on the partner. Asset productivity and damage postured by outflows and waste streams are the parameters of ecological supportability. Social manageability concerns well-being, security, and enhanced social conditions for representatives, and value inside the business (Moktadir et al., 2018).

7.2.5 Drivers to sustainable manufacturing practices—circular economy

The circular economy assumes an essential part in maintainable assembling rehearsals. The circular economy is a critical issue since it makes loads of vitality by avoiding heaps of waste. Information of the circular economy is basic. Information of the circular economy is an effective driver for maintainable assembling hones. There are additionally numerous subdrivers of this classification (Siemieniuch et al., 2015). Preparing and training are both critical for picking up information about the circular economy. Preparing is an effective instrument, and instruction by formal or casual means can assume a key part in picking up information. Significance ought to be

set on the accessibility of data. As the greater part of the exploration on the roundabout economy has been founded on created nations, there is shortage of accessible data regarding the matter of the roundabout economy for creating nations.

7.3 Circular economy idea outline

The circular economy idea draws on numerous different ideas, set up decades back, for example, spaceman economy, points of confinement to development, relentless state economy, execution economy, mechanical nature, and "support to support," among others. Nevertheless, the enthusiasm for the improvement of the Circular Economy (CE) idea worldwide has been restored just as of late, which is reflected in the principle wellsprings of data on round economy. These productions think about idea arrangement, vision creation, and plan of techniques. The accompanying meanings of circular economy have been found in the writing:

In a modern economy, material streams continue circling at a high rate without entering the biosphere unless they are natural supplements. A modern economy that is therapeutic by expectation intends to depend on sustainable power source; limits, tracks, and wipes out the utilization of poisonous chemicals; and kills squander through cautious plan. An economy gives numerous value creation systems which are decoupled from the utilization of limited assets; in a round economy, development originates from "inside," by expanding the esteem got from existing monetary structures, items, and materials.

Another characterization has been produced for the circular economy. Usage of database, keeping in mind the end goal to empower hunt of cases of reasonable methodologies for circular economy usage, among other conceivable databases utilizes situations as depicted beneath. The characterization respects the following:

1. Scope of the circular economy, characterized as a substance, material, product, sector or on the other hand system
2. Strategy name, number, and part of the value chain
3. Implementation level of the procedure, characterized as approach/planning/vision, research and development, knowledge and experience transfer, pilot scale, and market ready

Segments and frameworks can be either deficient esteem chains or a mix of a few esteem chains. The classification inside the class scope reflects diverse subjects for circular economy usage as recommended in the hypothetical methodologies and strategy records. Some of these hypothetical methodologies propose concentrating on frameworks or parts, while other on needed items, materials, or substances. The strategy name, number, and part of the value chain give capacity to gaze upward the system definition in the circular economy strategies database and the focal point of this system inside the circular economy value chain plot. On the other hand, the absence of systems or tried cases for a specific scope or some portions of the value chain can be

distinguished. The implementation level permits examining the accessible experience for various scopes furthermore, the development of the accessible techniques. The circular economy implementation database can likewise be utilized for data on methodologies accessible for a specific scope being referred to (i.e., metal) and for looking into which techniques are application-prepared.

The created databases can fill in as instruments for execution of the proposed in the writing hypothetical methodologies. Specifically, circular economy techniques database and circular economy implementation database incorporate methodologies also, usage cases, individually, for each piece of the esteem chain. The circular economy implementation database contains contextual analyses and the relating methodologies for different scopes of circular economy from substance to division and framework.

7.4 Business models—circular economy

Generally, the circular economy is tied in with moving from an arrangement of waste to one of "interminable genius." This more regenerative model bears a feasible business chance to effectively handle ecological needs, drive execution, advancement and aggressiveness, and invigorate monetary development and improvement. The worldwide textile industry is an effective nonstraightforward industry, and new companies confront numerous difficulties trying to enter the market. Regardless of worldwide progression in circular economy, and without shoppers requesting change from quick design and the absence of worldwide consistence administers, the industry is probably not going to move toward circular economy. The worldwide material industry is in the takeoff stage, multinationals have heard of the idea of circular economy, however, on account of the complexities of the whole framework, a move toward the quickening stage is probably not going to happen right away. Proposals that would support a move toward circular economy are worldwide ecological implementation laws, straightforward commitments about organization foundation, and making money-related assets for new companies for effective business development. Circular favorable position has recognized five circular plans of action organizations can use—independently or in blend—to create asset efficiency upgrades in inventive ways that additionally cut expenses, produce income, and improve client esteem and separation.

7.4.1 Circular supplies

The circular supplies plan of action is especially applicable for organizations managing rare products, in which rare assets are supplanted with completely inexhaustible, recyclable, or biodegradable asset inputs.

7.4.2 Asset recuperation

The asset recuperation plan of action uses mechanical advancements and abilities to recoup and reuse asset yields that wipe out material spillage and boosts financial

esteem. Cases incorporate shut circle reusing, modern advantageous interaction, and Cradle-to-Cradle outlines, whereby squander materials are reprepared into new assets.

7.4.3 Item life augmentation

The item life augmentation enables organizations to broaden the life cycle of their items and advantages to guarantee that they remain monetarily valuable. Material that generally would be squandered is kept up or even enhanced, for example, through remanufacturing, repairing, redesigning, or readvertising. By broadening the life expectancy of the item for whatever length of time those conceivable, organizations can keep material out of the landfill and find new wellsprings of income.

7.4.4 Sharing stages

The sharing stage display is fixated on the sharing of items and resources that have a low possession or utilization rate. Organizations that use this model can boost the utilization of the items they offer, upgrade profitability, and esteem creation. Cases of the sharing economy flourish, including transportation, cabin, and neighbors helping neighbors.

7.4.5 Item as an administration

Through the item as an administration plan of action, clients utilize items through a rent or pay-for-utilize course of action versus the regular purchase to claim approach. This model is appealing for organizations that have high operational expenses and capacity to oversee support of that administration and recover remaining an incentive toward the finish of life.

7.5 Circular economy: an opportunity for the development industry

In the meantime, troublesome trendsetters are embracing new plans of action utilizing circular economy standards and changing built-up business sectors with unbelievable speed. The use of circular economy to the development industry requires a framework thinking approach, one which gives a comprehension of the entire building life cycle and the development esteem chain, or as such, understanding the more extensive setting in which improvement happens. Just once the esteem chain is completely comprehended can the chances of the circular economy be figured it out.

For instance, we have concentrated on the material business, as in this area is blasting the execution of capable arrangements and the utilization of roundabout frameworks as far as item attributes and creation forms. We have seen that luckily there is an adjustment in the attitude of shoppers and numerous business people yet tragically despite everything we have far to go to achieve the point where it is proposed.

The idea of circular economy will be created, examining how the organizations of the material part have advanced up to now and how they are developing toward more mindful financial models without repudiating their monetary goals and dissecting their productivity. This chapter will not just clarify the preferences and the productivity and suitability of the textile industry organizations that take after a circular and supportable model, yet in addition see how it influences the advancement of business in the difference in mindset of a general public, progressively mindful and worried about the protection of nature and regard for human rights.

The development business has customarily taken after a take make arrange process. This has prompted various difficulties that should be overcome. Diminishing the measure of waste we create, be that as it may, is about much something other than requesting the correct amount of materials. Current development hones have squander incorporated with the plan. This is particularly evident where standard material sizes are utilized, for instance, sheet materials and conventional stone work.

7.5.1 Advantages of moving to a circular economy

By receiving circular economy plans of action, the concentration will move to sourcing reasonably, keeping up material profitability over the life cycle of improvements, and decreasing misfortunes of nonrenewable materials. This will deliver money-related social and ecological advantages. The market for a circular economy is developing, and it is evaluated that throughout the following 10 years, this will help monetary development by up to 4%. The circular economy will enable organizations to save money on crude material cost and also squander administration costs, in accordance with the EU Waste Framework Directive. In light of rising landfill assess rates; decreasing the volume of waste going to landfill would bring about considerable money-related advantages for organizations. There will be next to zero waste to landfill, and conditions will be advanced by natural supplements reintroduced into the biosphere through treating the soil furthermore, biodigesters. Development will be decoupled from asset extraction because of shut circles of specialized parts and increment of reasonable inexhaustible materials. Less assets will be separated in this manner decreasing the effect on the atmosphere.

7.6 Circular business model

To help the progress to the roundabout economy, administration, directions, and plans of action will assume a significant part. All the more imperatively roundabout plans of action (circular business models [CBMs]) would permit the maintenance of a benefit at its most astounding incentive after some time also, bolstering improvement of common capital. Diverse CBMs will be required at various phases of a life cycle of a benefit and may work autonomously or cooperatively. Effective execution of these plans of action will require activity from originators, providers, specialist organizations, temporary workers, and end-of-life organizations by sharing materials, frameworks, vitality, as well as data and administrations.

It is likely that for a roundabout economy to work, these extraordinary kinds of CBM should connect and cooperate. For example, on account of a light fitting, the "item as an administration" circular utilization plan of action implies the lighting maker holds responsibility for fittings, and is boosted to overhaul the fittings after some time to keep up most extreme proficiency. This in turn should profit the client as there ought to be no decrease in lux levels and they advantage from a la mode innovation. In any case, the full roundabout advantage is just acknowledged if the plan of action has took into consideration item and process configuration change, so that the light fittings are demountable and upgradable to diminish the utilization of virgin assets. No organization will work alone in a fabricated domain in view of a circular economy, and organizations have the chance to grow the administrations they offer or team up with others to amplify esteem.

For instance, a business which constructs their CBM in light of restoring and keeping up their items may need to collaborate with a "following office" supplier so they can screen and record where their items have been introduced, and afterward work with a coordination organization to guarantee the terminated items are returned. Innovation will be utilized to hold information on materials secured manufactured resources (i.e., building information modeling or BIM). At each phase of an advancement life cycle, there are openings and difficulties which should be tended to. Diverse partners will be engaged with giving the arrangements or may need to work cooperatively together.

7.6.1 Case study

Rent-a-Plagg is an organization that rents out open air wear in a ski resort, I inquire what that organization is at present contributing with straightforwardly through their own particular business, in wording of how they are influencing individuals to stay away from an utilization design described by asset wastefulness, and no exertion will be placed in noting how this can impact the clothing business in general.

Saiboo, is an organization that is giving human services workwear, which they later remember for reusing. Saiboo is presently running a material reusing research venture that, on the off chance that/when it succeeds, can possibly impact not only their own organization but rather the apparel industry all in all. In this manner, the concentration for this situation is not the same as the concentration in the event that, and the inquiry will be the means by which they can contribute, not essentially by their own tasks, be that as it may, what contributing twist off impacts this can have on the garments business in general in the event that/when their exploration venture succeeds.

7.6.2 Circular design—development and planning phase of a built asset

Products, systems, and the entire built structures are designed to last longer with a higher residual value. Therefore they shall be easier to maintain, repair, upgrade, refurbish, remanufacture, or recycle with respect to traditional ones. Additionally, new

materials can be developed and sourced, particularly bio-based, that are less resource intensive or fully recyclable. In the same context, new processes are being developed to increase the reuse potential and recyclability of construction and industrial products, by-products, and waste streams. There is an opportunity for designers to engage with potential partners who may have interest in the development (or parts of) post initial use. This may link with the "use" and "recovery" CBMs to ensure the benefit of the design is realized.

7.6.3 Circular use

Item to-benefit models permit a change from fabricating an item to various new openings, for example, giving renting and sharing administrations. Furthermore, they incorporate expanding the administration life of items and parts, giving administrations to encourage the following, advertising and exchange of auxiliary crude materials. This creates new open doors for organizations to both extend the customer base through client faithfulness and to build the long haul incomes through extra administrations, for example, upkeep, repair, and substitution of parts and segments.

7.6.4 Circular recovery

Income is produced by changing existing items into new ones including esteem, lessening expenses, or lessening waste. The advancement of a stage to upgrade turn around coordination is basic in this particular case.

7.7 New plans of action would permit

1. Greater control of asset streams through the esteem chain so the additional esteem can be recognized and caught.
2. Innovation through the inventory network so new substances can be produced, for example, business in squander taking care of restoration and switch coordinations.
3. Enhanced joint effort inside the store network among all performing artists.
4. Creation of administrations that catch profitable items/assets.

7.8 A new value chain

Another sort of significant worth chain is required for partners in the development industry to progress to the roundabout economy. Customary plans of action do not frequently support joint effort all through the esteem chain since organizations act freely of each other, once in a while considering the points of others in the esteem chain. Such a mind-boggling esteem chain for the most part has an organized approach where items and administrations are the stock of one organization and the receivable of

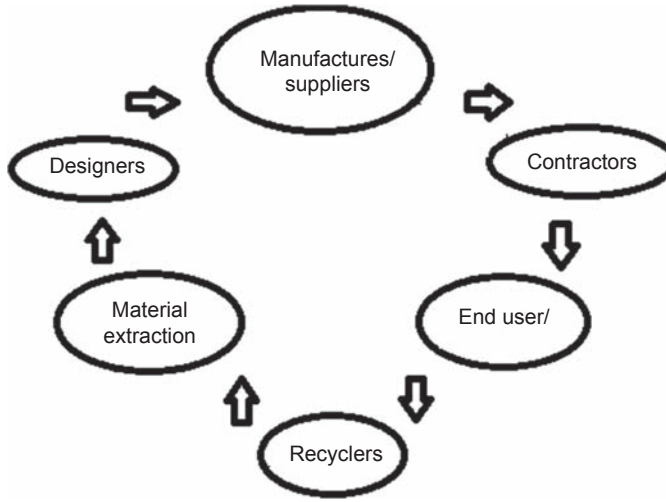

Figure 7.1 Opportunities and challenges across a circular value chain.

another. In this manner the dangers and qualities of an organization ought to be seen all in all with its esteem chain.

The whole esteem chain requires to cooperate for shared pick up. Items should be outlined with future uses at the top of the priority list, and all individuals of the esteem affix need to work with various plans of action, and levels of boost to give the customer longer term advantage and higher lingering estimation of their benefit. Opportunities and challenges across a circular value chain are shown in Fig. 7.1.

7.8.1 Asset holders and developers

Two of the enormous issues related with CBMs are dangers and vulnerability. Setting contract costs identified with the activity and upkeep of a building is to a great degree difficult to do. This is much more unpredictable while considering the long life expectancy of structures. In any case, various appealing openings exist. Renting models enable organizations to put certain benefits in operational expenditures instead of in capital ventures. This for the most part brings about smoother operational consumption and vital duty derivations, as working expenses do not qualify as capital resources and thus try not to devalue after some time. Renting models additionally maintain a strategic distance from huge forthright use and money might be authorized, enabling clients to divert their assets to different speculations. In the field of innovation, clients as of now incline toward not to contribute in items that are probably going to be outperformed in a matter of years. Subsequently, numerous organizations are moving their IT spending from their capital ventures to their operational expenditures, giving them greater adaptability and guaranteeing accessibility of frameworks that are dependably forward.

7.8.2 Planners

The part of planners in the round economy is probably going to turn into significantly more pertinent in regard to the conventional esteem chain. They may turn into a facilitator that coordinates capabilities and shared advantages over the diverse partners. Fashioners have the chance to design and evaluate circularity all through an advantages life cycle by creating inventive and practical arrangements. This incorporates surveying the land with the goal that it holds the most elevated esteem and additionally to guarantee that it is utilized at its ideal condition, giving social comes back to the neighborhood group and natural advantages. Directing thorough life cycle evaluation would be the initial step to address this. Configuration ought to be consolidated at or before arranging with other orders to guarantee that the item is intended for life span, adaptability, reuse, and deconstruction. Originators ought to talk about the future system of the working with neighborhood experts and the resource proprietors to guarantee reconfiguration is conceivable by utilizing a measured approach taking into account simple dismantling and get together of segments.

7.8.3 Manufacturers and suppliers

Difficulties for this situation identify with the absence of straightforwardness in the inventory network. In a round esteem chain, the substance of items should be known to take into consideration reuse, recuperation and reusing. Item identifications may give a response to the requirement for enhanced straightforwardness. As of now, most providers are hesitant to uncover touchy information that may decrease their aggressive advantage in the market.

7.8.4 Contractors

Progressively, temporary workers assume liability for execution due to prerequisites, for example, Government Soft Landings for open structures and customer ensures that improvements execute as expected. This gives a chance to engage with end users, to which guarantee profits by round arrangements are acknowledged and create learning about clients' work structures as a general rule. The temporary worker is at the heart of key choices and acquisition choices over the asset life cycle and will have chance to get circular materials. New advancements, for example, "item travel permits" and information inserted into virtual development models are expected to give confirmation of the lawfulness and nature of these materials.

Temporary workers as of now utilize construction and virtual models to increase productivity, decrease time and cost spent nearby. Further headways in digital tools will require close joint effort between esteem chain individuals, which the temporary worker could organize. This may help temporary workers to accomplish focuses for zero development squander and conceivably decrease well-being and dangers on destinations, utilizing robotized or human-helped machines.

7.8.5 Material extraction/recyclers/demolition

The part of pulverization temporary workers is probably going to change in a circular economy, with expanding center around getting to be "dismantling specialists" to discharge materials which will be generally secured in the building. There might be more joint effort among them and material extractors/makers to guarantee there are adequate amounts of material for exchange, regardless of whether it is reused or virgin. This adjustment in essential capacity will bring a progression of difficulties, for example, guaranteeing there are the aptitudes and learning to understand the full estimation of the materials. Engagement with the producers/providers will be vital to see how person items ought to be dismantled and giving these performing artists with an elective supply of material.

7.8.6 Opportunities and challenges across a circular value chain

A circular esteem chain requires all partners to contribute toward a result that accomplishes the best esteem for all gatherings, utilizing segments that hold the most noteworthy incentive all through the life cycle and limits misfortunes from the framework. Creating incorporated esteem chains could give organizations an upper hand later on. To acknowledge such a stage change in the esteem chain, it is important to decrease the newness of the partners with the ideas behind the roundabout economy. Working with the esteem chain can decrease the danger of debate furthermore, mistakes amid development, and additionally the utilization of working capital. Moreover, it enables providers to remain nearby to the customer by meeting future desires and empowers designers to remain near advancement.

The assembled condition offers an immense open door for organizations, governments, and urban communities to play a driving part in acknowledging circular economy without waiting for the change of the entire framework. Substantial cases that create in this space can go about as an impetus for a move in how our urban communities and urban regions work later on. In the meantime, troublesome trailblazers are receiving new plans of action utilizing roundabout economy standards and changing set up business sectors with unbelievable speed. These plans of action go for giving arranging and configuration to parts, frameworks, and at last the full resource keeping in mind the end goal to enhance its administration life. This incorporates particular answers for making strides in how the benefit is kept up, repaired, overhauled, and renovated or on the other hand remanufactured. A key arrangement of process through the esteem chain is required for this plan of action to build the reuse potential and recyclability of items, by-items, and waste streams.

7.9 Strategic business models

7.9.1 Waste management—synergistic plans of action

Waste management has generally given end-of-pipe arrangements, whereby expanding measures of disposed of materials are covered, dumped out adrift, or transformed

into powder, making the need for the extraction of further crude materials. These philosophies try not to make the best utilization of the waste as an asset or do not convey agreeable ecological results. The waste division is better comprehended as a vital part of the manageability motivation, requiring more all-encompassing arrangements that consider the ideas of maintainable generation and utilization and the round economy.

The waste business is presently perceived as an underutilized "asset industry" in its own privilege, with expanding center around waste having inborn monetary esteem. Formal and casual reusing rehearses have risen as a prevailing power, integral to generally waste administration programs in the created world. Noteworthy strategy advancements in waste administration have risen in the course of the most recent decade to address the developing interest for materials and mounting confirmation of natural and societal effects of our cast off consumerist economy. While a few arrangements go for transforming the traditionalist waste administration systems, others on a very basic level reconceptualize and reframe it inside and out. The universe of waste administration is moving far from routine landfill and reusing of both civil and modern waste toward coordinated waste approach. Programs including zero waste targets and 100% preoccupation from landfill are progressively noted with rising urban densities and land costs in real urban areas over the world. Supportability results, practical generation, and utilization practices and round economy programs all support new norms in administration structures and waste strategy mediation. Moreover, natural directions, material cost, and material shortage are additionally making an attention to ecodesign benefits in connecting end of life waste materials as reused/returned contributions to before generation stages.

7.9.2 Sustainable innovations

There are different definitions of innovations in the management and economics literatures initiated from different theoretical outlook. Different "innovation" definitions come from several researchers in the relation of fashion industry, which can be listed in Table 7.1.

Innovation occurs after a considerable time following an invention that is the solution to a problem; innovation is the commercially successful application of the solution.

7.9.3 New competition in the business models

Considering an organization working in the form of business, constrained development is essential because the advancement fixing is important to relaunch, reproduce, and reconsider at the entire authoritative level. It is vital to build up the innovative procedure in organizations, which are being human associations and living beings. The association culture which takes after a massive database tallying its experience, aptitudes, individuals' responsibilities is confined by the inherited code of business visionaries. As design history specialists say, occasionally one innovative, business person or

Table 7.1 Different types of definitions of "innovations"

Serial Number	Researchers	Definitions for innovations
1	Drucker (1985)	The specific tool of entrepreneurs, through which they exploit change as an opportunity (which is the source of innovation) for a different business or service
2	Ulijn and Weggeman (2001)	Creating something new and implementing it successfully at a market
3	Tom Ford	Trends in fashion history was changed with a mix of tradition and modern innovation
4	Marcel Rochas	The process by which opportunities are identified and exploited
5	Charles Revlon	Innovation as a new idea, practice, or object
6	Lowe and Marriott	Innovation is a process of creating, experimenting, transforming not only what is offered but the way in which it is offered—"the business model"
7	Schumpeter	Innovations are usually more important than inventions

creator, could change the world and fashion history patterns, in view of his/her effect on corporate culture, hierarchical skill, and advancement administration (Miller and Friesen, 1983; Covin and Slevin, 1991; Antoncic and Hisrich, 2003). Then again, corporate entrepreneurial conduct has additionally been perceived as needed for making ceaseless advancement and accomplishing upper hand in element markets and building hierarchical abilities that permit a firm to make the limit with respect to constant development.

In this unique circumstance, persuaded individuals go about as business people who can spot openings and make an interpretation of these to their hierarchical setting. As associations embrace more development strong types of arranging, the part of the center administration turns out to be more critical in managing the requirement for more inventive, responsive, and learning-focused associations (Pettigrew et al., 2003). As it were, enabling change-arranged initiative conduct and learning-focused culture build firm execution in associations, and by applying this approach, fashion firms can effectively deal with their ceaseless change nature of development.

As highlighted, with regard to cases from the form business over, the relationship between high performing firms and inventive business people is good with the writing which advocates that development expands firm execution, and in this way upper hand. The writing on advancement and enterprise proposes that fashion organizations and bosses need to show an abnormal state of imaginativeness to produce high performing firms with upper hand.

7.9.4 Significance of innovative administration for strategic business

In the design part, development is a constant and practically unending procedure; the accentuation ought to be on the need of advancement as a device of aggressiveness for a fashion business. In the field of item development, the market is continually searching for new items. Colleges ceaselessly grow innovations and endeavor hard to popularize their new advances. Achievement still relies upon the plan of action, displaying and back, which must include modern accomplices in administration (Yu et al., 2006). Other than adaptability, the issue of advancement administration picks up significance. Form organizations should endeavor to devise procedures for development since the effective introduction of new forms is progressively liable to be the aftereffect of such arranged methodologies. In taking note of the need for a vital approach, the industry is intensely mindful that not all things are conceivable and have learned by experience that new thoughts should typically identify with what as of now exists in the event that they are to succeed. The result of this is responsiveness could be a compelling substitute for the capacity to precisely foresee future patterns. Development is a basic component in endeavors by making new business action, in creating development, and in guaranteeing survival for a current business with a specific end goal to pick up a focused edge. In any case, the fact of the matter is that advancement is driven by imaginative and venturesome people and does not happen suddenly. Today, the matter of form requires complex administration strategies notwithstanding an abnormal state of innovativeness and advancement.

There are two measurements of "inventiveness and innovation" in the fashion business. The previous concern's item advancement identified with the inventiveness of form/material architects that is vital to make more grounded worldwide brands and world-driving, focused items. The innovation procedure includes five phases: recognition, development, improvement, execution, and dissemination (Maidique, 1980). The first of the three models of development is incremental advancement or ceaseless change, which signifies "enhancing existing" merchandise, procedures, or benefits and incorporates connected research and generation (Best, 2001). The second is radical advancement and means the "improvement of new" merchandise, procedures, or administrations of significant worth that have not existed already (Yu et al., 2006). The third is another model called "open frameworks" local advancement which speaks to firms, or arranged gatherings of firms, that have shown a territorial ability to advance and quickly reexamine items (Best, 2001). In addition, posturing new difficulties for advertising, irregular developments, and, somewhat less along these lines, progressively consistent advancements, make interruption the inward operations of an association. On the off chance that the development is troublesome, it may require a radical change in the association's administration procedures, for example, assembling, dispersing, and promoting. It may even need a total redevelopment of the association's plan of action and practices.

7.9.5 Future development

The multifaceted nature—and oddity—of the circular economy display raises various pragmatic difficulties that require specialists from various orders, including the characteristic sciences, building, financial matters, and administration, to address and resolve. To close generation circles, the circular economy must give the financial motivations to guarantee that postutilization items are reintegrated upstream into the assembling procedure. One of the obstacles that the round economy faces is that it is generally more costly to produce a strong enduring great than a comparable snappy and dispensable variant. This is an open decent issue: the advantages of delivering a less or a nonstrong great is private while the natural cost is open. Specifically, it requires changing the worldview of the straight economy where the outer costs identified with a progression of natural and human medical problems are separated from the creation and utilization of the products. Rather, these costs should be completely coordinated in the cost paid by the purchasers. Hypothetically, both the round economy and manageable advancement propose to disguise the cost of natural harm in gainful exercises. Nevertheless, the standard straight generation display just influences halfway endeavors about gathering and reusing waste. Conversely, the circular economy offers a more far-reaching approach, with each progression in the creation and helpful existence of the item, and its repair or disassembly, disguising both the cost of utilizing new material assets and vitality, and their arrival of contaminants that impact the earth and people. By thinking about a more full scope of generation and utilization exercises, the circular economy averts natural weight moving toward different exercises. In that viewpoint, the circular economy serves to characterize what ought to be disguised and can accordingly assume a noteworthy part in achieving practical improvement destinations.

7.10 Conclusion

Circular economy is by all accounts a promising idea since it has possessed the capacity to pull in the business group to manageable advancement work. It bodes well, that in the event that you remove an asset from nature and buckle down for it to wind up noticeably an item or an administration that has a monetary esteem, you utilize this value many times, not just once. This makes idealize marketing prudence. It is additionally basic and intelligent to contend that once one uses the esteem implanted in assets commonly, not just once similar to the normal practice in the linear material stream example of the worldwide economy, one decreases the virgin information and the waste and outflow yield of the financial action. Besides, numerous utilization the common biological system physical material and vitality stream demonstrate as the coveted vision of the human economy. The worldwide normal environment is physically shut furthermore, runs altogether on inexhaustible (or interminable) sunlight-based vitality, discharging just waste warmth (infrared radiation to space) as the "waste yield," which does not make a difference as the info source is interminable.

Circular economy business models are distinguished on two noteworthy measurements: the (1) client incentive and interface, i.e., the usage of the circularity idea in proposing an incentive to clients and the (2) esteem organize, i.e., the routes through which communicating with providers and revamping the claim inner exercises. Specifically, it creates the impression that these modes are not straightforwardly connected in a transient form, possibly speaking to examples of advancement of firms and businesses in embracing the circular economy. Rather, they appear to speak to simply extraordinary methods of selection of circular economy standards, which basically rely upon the readiness of the organization, i.e., the administration responsibility, to embrace circular economy standards. Especially for this situation, we bring up the need for future hypothetical and observational research to break down the impact of the administrative responsibility in detailing and setting up round situated approaches and goals, preparing inward assets and making mindfulness on the need of item configuration rehearses among all the performing artists of the inventory network, and in addition, directing their execution at all organization levels and overhauling the projects and activities in the light of the circularity that is accomplished.

References

Allwood, J.M., Ashby, M.F., Gutowski, T., et al., 2011. Material efficiency: a white paper. Resources, Conservation and Recycling 55, 362−381.

Antoncic, B., Hisrich, R.D., 2003. Clarifying the intrapreneurship concept. Journal of Small Business and Enterprise Development 10, 18−25.

Best, M.E., 2001. The New Competitive Advantage, the Renewal of American Industry. Oxford University Press, UK.

Bilitewski, B., 2012. The circular economy and its risks. Waste Management 32, 1−2.

Bocken, N.M.P., Short, S.W., Rana, P., et al., 2014. A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production 65, 42−56.

Covin, J.G., Slevin, D.P., 1991. A conceptual model of entrepreneurship as firm behaviour. Entrepreneurship Theory and Practice 16, 7−24.

D'Amato, D., Droste, N., Allen, B., et al., 2017. Green, circular, bio economy: a comparative analysis of sustainability avenues. Journal of Cleaner Production 168, 716−734.

Dobbs, R., Oppenheim, J., Thompson, F., 2011. A new era for commodities. McKinsey Quarterly 4, 13−15.

Drucker, P.F., 1985. Innovation and entrepreneurship. Practices and principles. Harper & Row, New York.

Geng, Y., Zhu, Q., Doberstein, B., et al., 2009. Implementing China's circular economy concept at the regional level: a review of progress in Dalian, China. Waste Management 29 (2), 996−1002.

Heyes, G., Sharmina, M., Mendoza, J.M.F., et al., 2018. Developing and implementing circular economy business models in service-oriented technology companies. Journal of Cleaner Production 177, 621−632.

Korhonen, J., Nuur, C., Feldmann, A., et al., 2018. Circular economy as an essentially contested concept. Journal of Cleaner Production 175, 544−552.

Maidique, M.A., 1980. Entrepreneurs, champions and technological innovation. Sloan Management Review.

Miller, D., Friesen, P.H., 1983. Strategy-making and environment. Strategic Management Journal 4, 221−231.

Moktadir, M.A., Rahman, T., Rahman, M.H., et al., 2018. Drivers to sustainable manufacturing practices and circular economy: a perspective of leather industries in Bangladesh. Journal of Cleaner Production 174, 1366−1380.

Murray, A., Skene, K., Haynes, K., 2015. The circular economy: an interdisciplinary exploration of the concept and application in a global context. Journal of Business Ethics 140, 369−380.

Pettigrew, A.W., Whittington, R., Melin, L., et al., 2003. Innovative Forms of Organizing. Sage, London.

Siemieniuch, C.E., Sinclair, M.A., Henshaw, M.J.C., 2015. Global drivers, sustainable manufacturing and systems ergonomics. Applied Ergonomics 51, 104−119.

Su, B., Heshmati, A., Geng, Y., et al., 2013. A review of the circular economy in China: moving from rhetoric to implementation. Journal of Cleaner Production 42, 215−227.

Ulijn, J., Weggeman, M., 2001. Towards an Innovation Culture: What are its national, corporate, marketing and engineering aspects, some experimental evidence. In: Cooper, C., Cartwright, S., Early, C. (Eds.), Handbook of Organisational Culture and Climate. Wiley, London, pp. 487−517.

Vermeulen, W.J., 2015. Self-governance for sustainable global supply chains: can it deliver the impacts needed? Business Strategy and the Environment 24 (2), 73−85.

Webster, K., 2013. What might we say about a circular economy? Some temptations to avoid if possible. World Futures: The Journal of New Paradigm Research 69, 542−554.

Wen, Z., Meng, X., 2014. Quantitative assessment of industrial symbiosis for the promotion of circular economy: a case study of the printed circuit boards industry in China's Suzhou New District. Journal of Cleaner Production 90, 211−219.

Xue, B., Chen, X.P., Geng, Y., et al., 2010. Survey of officials' awareness on circular economy development in China: based on municipal and county level. Resources, Conservation and Recycling 54 (12), 1296−1302.

Yu, W., Fan, J., Harlock, S.C., et al., 2006. Innovation and technology of women's intimate apparel. Woodhead Publishing Limited, Cambridge, England.

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Systems and models for circular economy

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8.1 Introduction

Textile industry is a multinational industry and is one of the dominating industries across the world that gives a tough competition in all the seasons. Fashion industry offers millions of job opportunities, generates globalised clothes as suitable to everyone in the world. Breakthrough in textile research is disposable clothes, produced in the early 20th century. Designing garments in one country, manufacturing them in another country, and selling them across the world is an increasing trend in textile industry. The time is to set out demanding particular garments through aims and actions of the textile system for better economic, environmental, and societal outcomes. They target linear economy, facing difficulties in current market due to poor infrastructure, supply chain, and values of their product. Owing to circular economy (CE), the same goals of conventional economic models are practical by proposing innovations in new start-ups and their product cycles. These changes at the niche level can alter economic profit of less organized industries. Because owning a resource is important as it belongs to the company instead of leasing the final product through linear business models. By creating "library of clothing" or "provision of unique codes" (bar codes) will help in reusing by-products such as plastics or wastes in CE.

A CE is an economic system that aims to redefine resources to be utilized, to be disposed for the growth on societal benefits. It is in contrast to linear economy, entails for the right consumption of finite resources and design of waste system to improve economic activity. The shift from linear to CE entails natural, economic, and social capital. The principles are to design waste system and pollution; to maintain products and materials in use; to regenerate natural systems (https://ieep.eu/). In textile industry, current practices involve in taking natural resources, making to a product, and disposing or exploiting them inappropriately. CE economic system involves in recovery of resources by extracting the maximum value of resources or raw materials for number of possible times to be processed, used at any scale and ends up in life cycle to regenerate. Prevention of textile waste is not a one-way approach but circular to meet business standards, consumer needs, and mainly environmental policies. The production of socio-benefit garments in circular system offers maximum efficiency from used textiles. Besides, minimum usage of resources results in greater productivity as well as employment growth that drives competition in delivering reused products with exclusive looks. This practice ensures resource scarcity in terms to preserve natural heritage and resource security in terms of environmental impacts to consumer on

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00008-X

consumption of reused textile products. In near future, a new set of business models can be developed in collection of waste, in infrastructure for operation, and in improvement of the quality of reused end product in circularity.

Challenges to overcome in the current textile system:

- To replace conventional business modeling in terms to delivery system
- Lack of policy management in textile industries about collection and processing
- Infrastructure disabilities for operation
- Improper disposal system
- Limited access to natural resources
- Unawareness of recycling across global standard
- Lack of textile supply chain
- Product quality and sustainability

These challenges are able to overcome by establishing circular business models professionally to deal collection of sources or textile waste according to existing policies, recycling units, and their process and by reutilizing them. It requires public sector procurement for both large-, small-, and medium-scale enterprises to refurbish textile market.

8.2 Circular economy

CE is one of the finest options that minimize negative impacts while transforming the way textile gets delivered. A point between decline in production growth and utilization of resources results in an incredible amount of wastage. Notably, landfilling textile garbage is not encouraged in circularity but through recycling; it expands pressure on resources. Such pollution-preventing measures (Han and Tyler, 2014) are significant not to discharge waste in the ocean and let them enter the food chain. Modern textile industries have initiated "circular fibers" as successive step of CE, catalyzing changes in fast fashion market. By mapping economic principles in the vision of CE, it eventually ends in supply chain management of garments.

8.2.1 Building blocks of circular economy

The true concepts behind CE lies on fibers as building blocks of the supply chain and a core that impacts the value chain. Current fashion system is a failure for its complexity within recycling and mobilizing to unknown business models. In CE, stakeholders play a vital role in global collection and investment in recycling systems. Thus, promotion of garments to clean, fair, and safe by CE is ease at any scale, whereas problems are fairly encountered by established business models through commercial and government policies. This model encourages collaboration between precompetitive brands in transition. Hence, a pool of knowledge is utilized in innovative design and consumer satisfaction to great economic value for the products. It facilitates competition for public tender for waste collection to reuse, to recycling, and to their cascaded usage.

Circular process requires advanced skills, set of information, and working frequencies. That begins from material selection to extract standardized components, premium design for last products, design to end life sorting, separation of products and materials, and various manufacturing criteria leading to economical successful circular design. Moreover, technical tools are linked in by-products and wastes exploring exercises. Volume leaders are inspired by vertical integration in circularity (Kirchherr et al., 2017). They seize significant market share. Therefore, CE is a profitable industrial production model that involves in delivery chain logistics, sorting, warehousing, risk management, power generation, and even molecular biology and polymer chemistry. It upgrades technology to detect leakage of materials, storage efficiency, treatment systems, and effective segmentation of end-of-life products.

Biological and technical metabolisms are to detect flow of industrial product components for continuous recovery of energy and nutrients. It is achieved through life cycles of materials with respect to local impacts which are safe to human as well as to environment. Composting and anaerobic degradation of biological-based materials are fed into living systems such as soil to gain economy. It eliminates waste but supply nutrients; often regenerates renewable energy to healthy diversity. In current systems, digital technology has the power to support the transition to a CE by radically increasing virtualization, de-materialization, transparency, and feedback-driven intelligence. Further section illuminates the existing strategies for companies to adapt circularity in practice.

8.2.2 Degree of implementation

The aim of every individual organization is benchmarked for the degree of transition through circular business plans, revealing scientific barriers to face business obstacles. Research has attempted to specify these barriers affecting circular concepts and their compatibility in transition paths. Transitioning in textile toward circular poses many questions. Few of them include the following:

- How to begin circular transition in new start-ups?
- What are their characteristics regimes to textile business in the lead?
- What are the technical barriers that textile industry is facing while shifting to circular?
- What is transition implementation theory in textiles?
- What is the extent of CE in multinational industries?

This chapter is an attempt to answer these questions and to provide phases of circular economic model for successful business.

Apparel industry is in need for sustainable production, consumption through a clear production practices, and logical coordination to implement business models. Circular transition replaces linear for shortening the life of material through incomplete waste system. Attempting fundamental shift to financial and service-oriented industry practices toward circular is a timely need (Guldmann, 2016). In which, the critical steps in transformation can be identified while implementing new business models, technological innovation, radical collaboration, and rapid acceleration. However, retail and reuse sectors initiate rethinking of textile product and their value chain for immediate action.

In circularity, raw materials are maintained in a circular motion involving processing, finishing, selling, collecting waste, recycling, reprocessing, reselling as second-hand garment, and ends with regenerating. Such a systemic approach welcomes all garment industries to aggregate and overcome these obstacles by helping/working each other. Circular model builds restorative approach for an increased exposure, intensified efforts, and upgraded technologies to create systemic collaboration and convergence toward a new normal.

8.3 Linear to circular

Industrial scale circular model is in trend, preserves nature capital, optimizes them for effective sale as the traditional goal is to producing end-of-life product. Circularity in textiles eliminates the use of toxic chemicals and polluting waste through foster and superior production system. Sustainability is CE's main principle, alter the product-oriented business models to service-oriented business models. Certainly, it increases the number of products sold from various initiatives; promotes their life span; reuses them before losing virginity as much as possible. Product service system (PSS) is to connect market demands (Baruque-Ramos, 2017) for certain textiles to manufacturers and customer's needs to retailers. In this way, developing a business model is expected to be environmentally friendly, focusing on sustainability through commercial space for repurposed products. On the other hand, wasteful products on street are minimized through resource-efficiency circular model.

Current linear economic system makes products for consumers to use and dispose, whereas the virgin material undergoes processing, producing a final product, but not ever considering environmental and social law or issues. Hence resulting in nonsustainable economic system, recovery of material is tough. Therefore, most of the industrialists would like to turn to sustainable products in contrast to linear, keep their sources for long-term usage at the end of service. It is an evidence to support transition from old, traditional linear to circular systems (Ellen MacArthur Foundation, 2013).

PSS is a serious involvement to control nature capital and finite stocks loss while balancing renewable resource flows. As the different forms of PSS limits the cost and quality of the material, product-oriented model is not advisable. In real contributions, PSS guarantees resource efficiency and circularity. Indeed, use-oriented PSS prompts less careful use, as product-oriented PSS do not extend the product sale. However, use-oriented PSS does not favor CE to be happening (Michelini et al., 2017). This was investigated in the result-oriented model, presenting the features of most popular interpretation to other business models. The result-oriented is sophisticated, service-oriented, possible to implement circularity since the customer pay producers for the products not for its consumption.

Optimizing resource yields while the final products/materials undergo continuous circulation for the highest utility may come across obstacles technically or biologically. The shift of products from firms to service leads for maximum consumption

is resulting in transition from product-oriented to service-oriented business model. A secret behind profit of textile industries lies in selling the units of service. Often, it combines neighbor companies where the number of products sold is increased via reuse of any part of the materials or components to extract the values of products (Ræbil and Bang, 2017). It is advantageous for producers to reuse or resale since they have intellectual right or ownership of the products.

Finally, negative impact of secondhand textiles that undergo environmental safety measures distinguished from old linear to circular requires sustainability. PSS is designed for continuous recovery and reutilization of products through life cycle assessment (LCA) of materials. LCA is a technique that analyses environmental impacts associated with material flow at all the stages including processing, manufacture, finishing, distribution, sale, use, disposal, repair, regenerate, and recycling. It assesses the burdens associated with the specific production and service for final decision. Thus, proposed change resulting from the flow model of technical system can be implemented in the economic market.

8.3.1 Advantages in circular economy

- LCA tunes built economic activity or business strategy
- Applicable at all the stages of product life
- Reduces environmental burdens through ecological balance
- Assures long-term systemic shift
- Provides a clear variation from technical to biological cycles

8.3.2 Challenges in transition

- In general, producer establishes a business model based on cost perspectives that are expensive while transitioning from linear to circular because circular is labor intensive.
- Eco-circular economy is another target that requires design, return logistics, and design processes which are expensive in practical.
- High complexity in existing model (circular business) requires well-suited remanufacturing that is in need to be refurbished.
- In case to revenue prospects, the estimation of unit of service is very difficult.
- Innovation speed is low as resulting in impracticability of make−reuse.
- In comparison, leased products are not used as possible as owned products.

In context, PSS is suitable for transition from linear to circular, i.e., for resource efficiency while coupling with circular business models. The transition from linear to circular ensures no more sells for profit, but sells of units of services (Korhonen et al., 2018). Since this subject is new in textile market, CE is an evidence in response to the inefficient management of the resources in the traditional linear model. Circular economic system is conductive with the aid of government sectors but requires intentional design to minimize environmental impacts. Circularity in result-oriented PSS is transparent, paid for the provision of service, managing components, modeling them for customer satisfaction.

8.4 Validation of circular economy

CE is a social enterprise, organized as cooperation, aiming at the scalable acceleration and practical implementation in boosting new start-ups for sustainable and innovative business ideas for near future applications.

8.4.1 Methodology

This section comprises of governmental, business policies retrieved from literature and organizational documents (government, businesses, and industry reports). Commercial information on primary goals which drive CE was retrieved from individual organizational website. Textile industries in regarding to new start-ups for CE consider opportunities and barriers which have to be altered for circulation. That is wide while developing business models to consultancies where stimulation of innovative ideas plays a major part. By engaging to board of each national activities in textiles, the cooperation between businesses, research institutions, and government can be established for mutual benefits. It is an independent move to support the transformations of organizations and their clients to shift toward CE. Therefore, theoretical framework is used to validate concept-oriented models, i.e., transition theory and barriers to encounter in environmental activities. This section provides knowledge on functionalizing transition-related concepts and their interconnectivity to barriers in business.

8.4.1.1 Transition theory

Start-up transition is significant to assess any positive outcome because that is able to emphasize the complexity of societal systems with lock-ins and interrelatedness of subsystems. The current regime can be modified through "extent of change" at sociotechnical level. Transition takes long term, for example, 20–25 years to be successfully implemented. A systemic change at this timescale deals with societal level but not economic level. Therefore, societal transitions focus at understanding shifts in societal functions, behavior, dynamics, and technologies in a broad sense (Sandström et al., 2014). On the other hand, interaction between companies revealed poor understanding of the societal environment from where different levels in landscape, regime, and niche to be studied by the multilevel perspective (MLP).

Coming to interactions, first is new start-ups, build their own ideas at niche level, i.e., novelties outside the regime; second is grand multinational textile companies which involve in determining the sociotechnical pathways to track transition path at every level. Multinational companies are dominant actors in direct pathways including structures, infrastructures, behavior, and lock-ins and can add insight in future transitions (Snoek, 2017). Therefore, encountering specific problem in shift toward CE using diffusion line is easy. The development of transitions is studied by MLP that drags attention to characteristics of start-ups. The right phases of CE in implementation are accessed by creating link to business and transition. This reveals gradual success of

societal change in terms to ecosystem services. Sustained dynamic system is an association of multivariable, namely, the economy, technology institutions, culture, and ecology in transition theory, resulting in future textile market demand.

8.4.1.2 Sociotechnological systems

The users of textile are more aware unlike ancient times, requesting technology support to embed in gaining knowledge on practice of objects and less spending time. Systemic social environment is a platform which connects social groups to technology for ease interaction. In other words, limitations to innovation in stable system are viable through interdependency of societal systems, subsystems, and institutions. A regime is powerful, sharing set of beliefs, user practices, and infrastructure facilities for dominant textile market. Regimes are large communities unlike niches that stabilize the characters of specific organizational field. Both of them share a common rule precisely. Those rules are regulations of laws; behavioral norms; innovation definitions and agendas. Cognitive rules are limited opportunities that make final decision in social network and fixed structures. Interaction between processes can occur in three levels: niche innovations at a microlevel, sociotechnical regimes at the mesolevel, and sociotechnical landscape at the macrolevel. Technological niche is radical, encourages novelties emerging at microlevel. The development of landscape can affect small network.

8.4.1.3 Barriers in circular economy

CE is a service-oriented business model, shifting business toward environment-oriented service. Experiencing barriers in environmental activities is not new, investigated enough for small- and medium-sized enterprises (SMEs). The result is divided into internal and external barriers. Occurrences of any one of them are bitter truth in implementing CE. However, environment-model prevents CO_2 emissions and their mobility to food chain in significant amount (Ritzén and Sandström, 2017). Shifting causes improved resource productivity around 3% which is totally relevant to business. But specific restrictions are found in transition theory that combines transition pathways and specific barriers in research. Adjustments are proportional to product specifications. Extension of utilization of product ends with reduced utility of resources is obvious. Processing fewer resources, coupling them for multiple uses can extend the end-life of product while simultaneously slowing resource loops. It tends producer to increase likability for the product, extended usability, reliability, and durability for the product. These products do not easily fail in long-term use.

There is another strategy to slow down resource loop, focuses on extension of life span of garment, repair and maintenance to fix the service when garment is back to producer for regaining perfect condition. Maintenance is the inclusion of upgradability of garment and its adaptability through services, checks, and updates. Therefore, future innovations are suggested to adapt for “standardization and compatibility.” Creating opportunities for disassembly or reassembly of parts of the garment is important instead designing business models.

General obstacles

- Common restrictions in business model in an alliance for green activities
- Vested interests of the company
- Lack of cultural acceptance
- Lack of consumerism
- Dependency on external suppliers (business)

Internal barriers

In general, internal barriers are categorized into technical, operational, financial, knowledge, and information barriers.

Technical barriers

- Lack of infrastructure is a primary factor, happening during shift from linear model toward circular in SMEs. Linear regime dominates infrastructure, keep the infrastructure locked in. Hence, organizing infrastructure is important while moving toward circular.
- Extraction of resources while attempting extraction of values from various sources of raw materials.
- Lack of standardization without normalizing product operations such as use of a recycle-machine which is cost-effective in SMEs.

Operational barriers

Accounting system is an important functional barrier that faces lack in stock or inventory available for maintenance. According to consumer needs, processing time for remanufacturing and repair operations must be taken care of.

Financial barriers

- A lack of capital to shift toward circular; cost to change infrastructure; implement CE in the life cycle.
- A lack of access to components in stock; a huge storage.
- Return of products; collection for reprocessing activities are expensive.
- Monitoring the resource flows and updating the product's life cycle of a product at every stage is difficult.
- Production services of business seem often a financial threat.
- Uncertainty is risky to comply these activities when entering a market.
- The lack of access to sources of funding, finding new methods of financing green innovations is also a significant barrier, as starting a company is difficult without the necessary funding to do so.

Knowledge and information barriers

- Establishment of CE is dependent on capabilities and information. Lack of them is a major risk for start-ups, as they must expertise in current infrastructure of the regime. Otherwise, developing new technologies and practical implementation will become barriers.
- Online marketing scheme seems favorable for customer needs. Lack of knowledge about the benefits of shifting towards a CE will hinder the transition.

External barriers

Sharing information between multinational companies is again risk due to the competitive nature of industries with traditional markets. The idea of new business cycle is helpful to convince costumers. Vision of the business model is again risky if not consumers need to have a "willingness to pay" a higher price for sustainable clothing (a report on Sustainable Design, 2017).

Societal barriers

- Societal barrier is associated with environmental activities, studied from SMEs. First is the lack of awareness about environmental issues of consumers and product chain. Customers must recognize that CE is the way forward, right path for any incentives to change.
- The idea of the abundance of materials in society is another barrier related to consumerism.

8.5 The garment supply chain

The garment supply chain comprises organizations, people, activities, information, and resources to sell garments or their service from supplier to customer. This system involves in the transformation of natural resources, raw materials, and components into a finished product. Sophisticated supply chain systems deliver products to the customer and encourage them to reenter supply chain at any point where residual value is recyclable (Saidani et al., 2016). In implementing CE, value chain of product plays a crucial role which is being complex in actual fact, demanding dynamic supply network. The oversight of materials relies on their information and finance, processes from supplier to manufacturer to whole to retailer to consumer. These product flows are monitored between companies, increase the demand for cooperation. The concept of supply chain in textile industries follows two core ideas. They are supply chain performance and quality assurance, and efficiency.

The financial and market objectives of supply chain management is divided into internal supply chain, referring the chain of activities within a company, offering a product for market price to customer; external supply moon, referring to face environmental factors that can have a direct and indirect effect on the supply chain.

8.6 Objectives

1. To help mitigate risks to competitive business in the marketplace associated with acquiring raw materials and delivering products or services.
2. To assure quality through inventory buffers, increased profits, reduced costs, and increased efficiency.
3. To ensure increased outfit, shipping options to mitigate risks in delivery.

The roles of supply chain management in CE are service oriented, system oriented, competitive, and efficient.

- It will result in minimizing the time for operation and processing.
- It will result in visibility between companies and their products.

- It will upgrade the quality of product.
- It will improve the visibility demand.
- It will reduce transportation cost as well as warehousing cost.

Value chain is as well influential in small and big companies in this field, either organized or unorganized. Since the supply chain is complex and dynamic, transparency in fiber production, fabrication, distribution, and retailing is hard to manage. Mechanical and technological units in the unorganized sector are hard to forecast the customer needs and future markets. To avoid this, they can coordinate with other companies in order to fulfill customer and market needs, where the synchronization performs well. They are evident for successful implementation of CE in textile market.

8.6.1 Cooperation within supply chain

Cooperation within supply chain of SMEs comes across several barriers. Importantly, dependencies of companies on external suppliers lead to lack of or low-level trust between partners. But a closed circle between companies ensures transparency. Finding partners in both supply and demand is an obstacle due to lack of resources, support from partnered companies in environmental engagement, and final share of loss if occurs. Short time frame courses of any business model will improve profit, infrastructure, and external stakeholders in terms of recovery and operation schemes.

8.6.2 Regulations

The role of legislation and regulation is essential for the environmental performance of SMEs. In spite of command-and-control, proactive environmental activities will reduce the environmental impact. For this purpose, companies must be aware of the added value of engaging in environmental activities and prefer to wait until legislation is implemented, especially among SMEs.

8.6.3 Limitations

- The utilization of natural resources or biobased materials and assessment of their environmental impact is difficult.
- Although LCA contributes environmental sustainability, it must be properly comprised of economic and social dimensions of sustainability in terms of critical research analysis of CE.
- A huge amount of resources with limited emissions while processing materials cannot be controlled at all the stages so-called thermodynamic limit.
- Spatial economic system is problematic when shifting the product life cycle.
- The usage of short-term nonrenewables is difficult to build long-term renewable infrastructure.
- Rebound effect and boomerang effect in physical scale of the economy are hard to fix.
- Path dependency while retaining market position and lock in and physical flows of materials and energy.
- Social and cultural limits in handling waste, management, and utilization.

8.6.4 Transparency in textile sector

Few multinational companies have given insights into their supply chain by making transparency. Their willingness to contribute increased transparency and sustainability instantly reflects in profit-oriented business models (Amui et al., 2017). Nontransparency begins from the complexity of the manufacturing infrastructure. Factories are often contacted to textile manufacturers, is tough to build working condition. And this leads for number of contraction to textile owners, profiting from big order with lower price and faster delivery. Complicated infrastructure of manufacturing factories, processing plants, and second tier suppliers is an indication to inspect government policies or regulations which may become transparent.

8.6.5 Niche remanufacturing

Remanufacturing and upcycling of materials obeys make-made reuse strategy. Likely, leftover textiles such as discarded linens are used as vintage fabrics to produce aprons, banners, raincoats by a steam laundry. Traditional craft skills are to reuse discarded materials in a distinct design for exclusive product looks. The unique trait of companies in remanufacturing loops is resulting in a premium sales price with the unique designs, developing business models will support materials from both within and between industries. Thus, the remanufactured textile gains attraction in market, representing the principles of circularity system. These are reassured with high quality of product having no chemical contamination, clean and fitting (www.suschem.org). Large volume textile recycling system is operated by collecting waste from collection bins at common places to reprocess. Those reused in the domestic market can be resold and half of them can be exported. Some of them can be used for threads, fibers, and synthetic felt and for energy recovery.

The charity organizations make profit out of secondhand clothing through sales. The textile collection programs will teach how to use garments responsibly and its value to customers. They offer discounts to customers as returning their old clothes. This collection system improves in-store traffic and customer loyalty. Besides, the used garments are sorted to attain significant economic return. Cascaded use is important in circular business model, that secondhand clothes undergo subsequent loop of remanufacturing and end up in the outermost loop of recycling.

8.6.6 Biological loops

Technical/biological loops are of particular interest to circular business models, where the municipality in few countries has examined how circular model works in wear services. Thus, the materials purchased by the municipality would be ill-suited for promoting the closed loop services. The existing policies are inappropriate to fulfill quality requirements of wear at the operating stage. For instance, uniforms of any organization or schemes to supply uniforms to labors is a consecutive loop, maximizes lifetime of textile wastes. Therefore, a new policy in public tenders has been reframed

in to circular requirements for work wear that enable other authorities to build business models according to their loop. Such quality of material is developed from its cycle and is vital to safeguard customers.

8.7 Conclusion

Literature indicates that "circular economy" is recent and new in the profession of textile waste collection. Waste management practices in linear economy are contrast to circular that collection, recycling, and disposal of textile waste has disconnected from end-life of a product. The understandings of how to integrate CE will be beneficial to environment through recycling strategies. Productive use stands for discarded or least fractioned material to sort out issues related to barriers, drivers, opportunities, and risks. Logical recycling is viable for societal economics. They may claim for legislative incentives for optimized system of textile wastes and landfill tax. Network innovation, partnerships, and collaboration may accelerate adaptation of circular economic industrial clusters.

Consumption behavior of public is also accessible for rewearable and low-grade nonwearable clothing with appropriate strategies developed by government officials. Financial security in order to coordinate networks and schemes must be mitigated to product specific. Guarantee price for nature capital must be consistent as closed loop CE is ensuring commercial viability and the removal of regulatory uncertainties and barriers. Besides, investments in research will break the cross-industry collaboration in recycling end products. But they would be market friendly secondary resource, easy to track and organize supply chain logistics. Such innovation-friendly CE model is in near future, applicable to local and urban levels of textile industries.

References

Amui, L.B.L., Jabbour, C.J.C., Jabbour, A.B.L., Kannan, D., 2017. Sustainability as a dynamic capability: a systematic review and future agenda toward a sustainable transition. Journal of Cleaner Production 142, 308−322.

Baruque-Ramos, J., 2017. Social and economic importance of textile reuse and recycling in Brazil. IOP Conference Series Materials Science Engineering 254, 192003.

Debbie Moorhouse, D., Moorhouse, D., 2017. Sustainable design: circular economy in fashion and textiles. Design for Next 1948−1959.

Ellen MacArthur Foundation, 2013. Towards the circular economy: economic and business rationale for an accelerated transition. Journal of Industrial Ecology.

Guldmann, E., 2016. Best Practice Examples of Circular Business Models. The Danish Environmental Protection Agency. ISBN: 978-87-93435-86-5.

Han, S.L., Tyler, D., 2014. Circular Economy Stakeholder Perspectives: Textile Collection Strategies to Support Material Circularity. Horizon 2020 Research and Innovation. https://ieep.eu/.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. Resources, Conservation and Recycling 127, 221−232.

Korhonen, J., Honkasalo, A., Seppala, J., 2018. Circular Economy: the concepts and limitations. Ecological Economics 143, 37−46.

Michelini, G., Moraes, R.N., Cunha, R.N., Costa, J.M., Ometto, A., 2017. From linear to circular economy: PSS conducting the transition. Procedia CIRP 64, 2−6.

Ritzén, S., Sandström, G.O., 2017. Barriers to the circular economy − integration of perspectives and domains. Procedia CIRP 64, 7−12.

Ræbil, U., Bang, A.L., 2017. Rethinking the fashion collection as a design strategic tool in a circular economy. Design for Next 589−599.

Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., 2016. How to assess product performance in the circular economy? Proposed requirements for the design of a circularity measurement framework. Recycling 2 (6), 1−18.

Sandström, C., Berglund, H., Magnusson, M., 2014. Symmetric assumptions in the theory of disruptive innovation: theoretical and managerial implications. Creativity Innovation Management 23, 472−483.

Snoek, S., 2017. Circular Economy in the Textile Industry. Transition theory in Dutch start-ups towards a circular economy.

www.suschem.org.

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Circular economy in textiles and fashion—the role of a consumer

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9.1 Introduction

For many years, we have been following a so-called linear economic model, which is based on a simple "take-use-dispose" scheme. We are producing and consuming at an increasing rate, using up more and more natural resources, generating more and more waste, creating more and more serious environmental and social threats. It is becoming clear that this "linear" formula is coming to an end, as natural resources are exhausting, prices are fluctuating, economy is becoming dependent on suppliers from other countries, and threats for ecological and social balance are rising. The need to abandon the linear economic model in favor of circular economy (CE) is therefore becoming increasingly urgent. The CE model entails utilizing resources rationally, to ensure that (EllenMacArthurFoundation, 2013):

1. the value of products, materials, and resources is retained as long as possible, while the production of waste is minimized;
2. materials contained in the waste which is already produced can be reused.

The change from the linear to the circular model requires knowledge, awareness, and engagement of all market participants: manufacturers, technology designers, consumers, and legislators (Fig. 9.1).

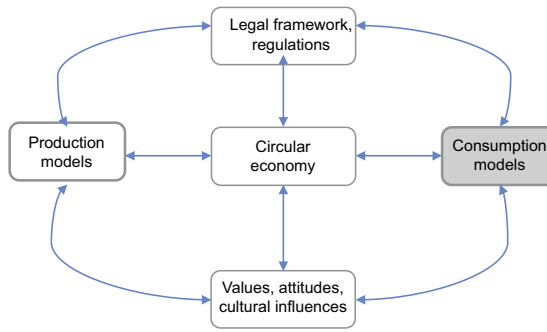

Figure 9.1 Interrelated market connections for the circular economy.

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00009-1

The speed and scale of the change will depend on knowledge, awareness, and engagement of all market participants; it will involve the whole product life cycle, from design to utilization.

However, consumers will assume a special role in this transformation; the speed and success of these changes will depend on their choices, on the amount and quality of products they buy, on their openness to new business models, and on the manner of dealing with used products.

Challenges of the transformation leading to CE are related to every area of contemporary economies, but each branch of industry will have its own peculiar problems and methods of solving them. Peculiar features of individual industries will therefore require individual approaches and careful analyses.

The limitations of the linear economy model are particularly noticeable in the textile and clothing industry. Textiles and clothing are, next to food, one of the most basic groups of consumption goods; they accompany people from the moment of conception till death, being largely responsible for their well-being and health. For years, we have been observing the rising demand for relatively cheap clothing which is used for increasingly shorter periods of time. This results in increased production and a growing demand for cheap, easily accessible textile raw materials, as well as in the growing amount of textile waste.

The aim of this chapter is to assess the role of consumers in the transformation toward a CE, as well as to identify and assess the factors determining their behaviors in this area.

9.2 The need for a circular economy in textile and clothing industry

The textile and clothing industry plays an important role in the European manufacturing industry, employing 1.7 million people and producing a turnover of EUR 166 billion. The sector accounts for a 3% share of value added and a 6% share of employment in total manufacturing in Europe (EC, 2018). It is also one of the biggest industries, globally worth over $450 billion, in terms of nominal sales. However, the sector is also considered as one of the most polluting (Agrawal et al., 2013; Resta et al., 2016). The main environmental problems associated with the textile and clothing products are typically those associated with energy, water and chemicals consumption, direct CO_2 emissions, and solid waste (Resta et al., 2016). Those negative impacts on the environment occur with varying intensity in different stages of the textile or clothing product life cycle, with the different role of the consumers in their creation. The biggest consumer's direct impact is associated with the use and disposal phase (Table 9.1).

In the textile and clothing industry, the factors of special importance for shaping the current and future situation of the transformation toward a CE are fast-fashion culture and consumerism which results from it. These trends are the consequence of dynamic changes occurring both in production and in consumption. The fast-fashion model is the consumers' reaction to the accelerating pace of life; it involves their expectations of

Table 9.1 Environmental problems related to life cycle stages with the biggest negative impact from the producers and consumers

Environmental problems	Product life cycle with the biggest impact	
	Production	**Consumption**
Energy consumption	Production of man-made fibers, yarn manufacturing, finishing processes	Use phase: washing and drying clothes
Water and chemicals consumption	Fiber growth, wet pretreatment, dyeing and finishing activities	Use phase: laundry
Solid waste	Textile/clothing manufacturing	The disposal of products at the end of their life
Direct CO_2 emissions	Transportation processes within globally dispersed supply chains	

Author's analysis based on Resta, B., Gaiardelli, P., Pinto, R., Dotti, S., 2016. Enhancing environmental management in the textile sector: an Organisational-Life Cycle Assessment approach. Journal of Cleaner Production 135, 620–632.

greater flexibility of clothing companies, fast delivery, and new products at affordable prices. It is also a new, attractive business model which has contributed to the success of many clothing brands. This model is supposed to satisfy consumers' current needs as fast as possible, and at the same time it significantly depends on creating these needs artificially, on stimulating the demand for "disposable" products which can be immediately consumed; this model is based on thoughtless consumption which blindly follows trends (OLIVER_WYMAN, 2015; Remy et al., 2016; Sempruch-Krzemińska, 2014).

The fast-fashion model requires a significant reduction of costs, which allows to maintain relatively low prices of clothing. It also calls for speeding up production and delivery, while ensuring the possibility to increase the number of collections each year. Zara offers 24 new collections of apparel yearly; H&M offers from 12 to 16 collections, a new one every week. The average number of new collections introduced by clothing companies every year has risen by more than 200%, from 2 in 2000, to around 5 in 2011. Simultaneously, we have observed a decrease in the prices of clothing in relation to other consumer goods (Remy et al., 2016).

These factors induce constant increase in clothing production based on conventional, relatively cheap, and accessible raw materials; they also lead to constant growth in consumption. In the last 14 years, the number of clothes bought by an average consumer rose by 60% every year, and the global production of clothes doubled; what is more, 15 years ago people wore clothes for twice as long as today(Remy et al., 2016).

It should be remembered that, although production and consumption are faster, some factors do not change: fiber takes the same amount of time to grow (cotton needs about a year), no matter how fast the product enters the market; it is difficult to reduce the time of cleaning, bleaching, and dyeing. Accelerating production and consumption

inevitably leads to high environmental and social costs. Faster manufacturing of cheap clothes is possible only due to the exploitation of the workforce and natural environment (Fletcher, 2007; Koszewska, 2011a).

All this results in the constant growth of demand, which in turn increases the production of conventional textile raw materials and creates textile waste, which is difficult to recycle. The predicted growth of global population, especially of middle class, will further aggravate the situation. According to data gathered by the United Nations Population Fund, the world population has reached 7550 million in 2016, and is increasing by 1.2% every year. The speed of this increase is highest in Africa: 2.7% (UNFPA, 2017). At the same time, OECD estimates that by 2030 the middle class will amount to almost 5 billion people, while in 2009 it was 1.9 billion (OECD, 2011).

According to the Ellen MacArthur Foundation, yearly consumption on emerging markets is expected to rise from USD 12 trillion in 2010 to USD 30 trillion in 2025 (EllenMacArthurFoundation, 2012).

All these factors clearly indicate the necessity to change contemporary production and consumption models, from the linear model to the CE model (Fig. 9.2).

In the case of textile and clothing industry, which is characterized by a particularly long and globally dispersed production chain, it is a very tough challenge. It will require fundamental changes in the business models of clothing companies. The stage of product design will be crucial because the success of "closing the loop" in consecutive phases of its life cycle will largely depend on it. Durability, universality, as well as the possibility of recycling the product or recovering raw material from it will depend on the choice of raw material, on clothing construction, and on finishing processes. Commercial and technological viability of recycling largely depends on taking this phase into consideration at the stage of devising and designing the product.

Another crucial phase is collecting and sorting used clothes; it will decide how much of the precious raw material will be recovered from textile waste and how much will end up in landfill sites. Introducing positive changes in this area (increasing the recovery of raw material and decreasing the amount of landfill waste) will depend

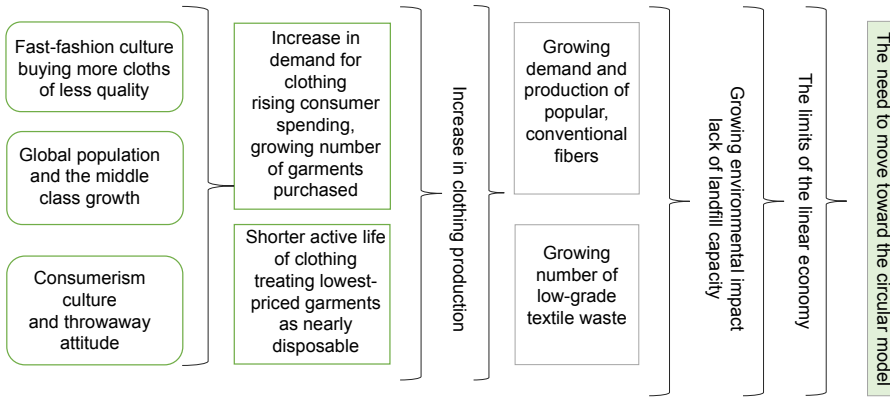

Figure 9.2 Consumer trends leading to the limits of the linear economy.

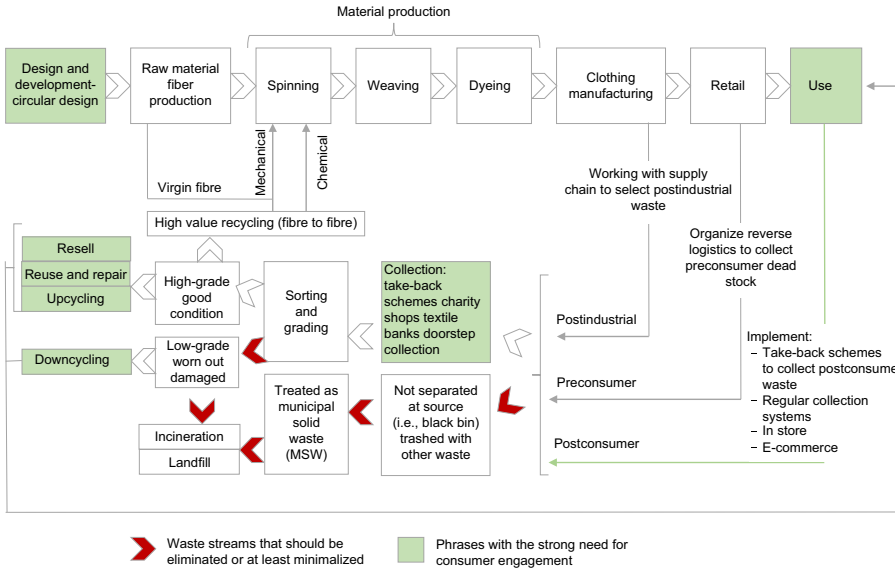

Figure 9.3 Phrases of the textile and clothing products' life cycle with direct consumer's impact.

on creating the effective systems of sorting textile waste and on the technologies allowing to recover raw material which account for considerable raw material diversity in clothing and textile products (common use of raw material blends: cellulose, protein, synthetic polymers) and for the composite structure of products (layered structure, e.g., of sportswear, or textile composites, e.g., for floor covering).

These changes will also be largely determined by consumer behavior. Fig. 9.3 presents the stages of textile and clothing products life cycle in which the engagement of the consumers may have a significant direct influence on positive changes, i.e., closing the loop and moving toward a CE.

9.3 The role of a consumer in the transformation of textile and clothing industry toward a circular economy

The role of a consumer in supporting the transformation of textile and clothing industry toward a CE will concern a few fundamental aspects (Fig. 9.4):

1. Openness to new business models, which involve activities such as sharing products, buying "user experience service" instead of a product itself (product service, e.g., leasing jeans instead of buying them), or being open to innovation, e.g., using 3D printing in textile and clothing industry (Lewandowski, 2016; Gullstrand Edbring et al., 2016; EllenMacArthur-Foundation, 2015).

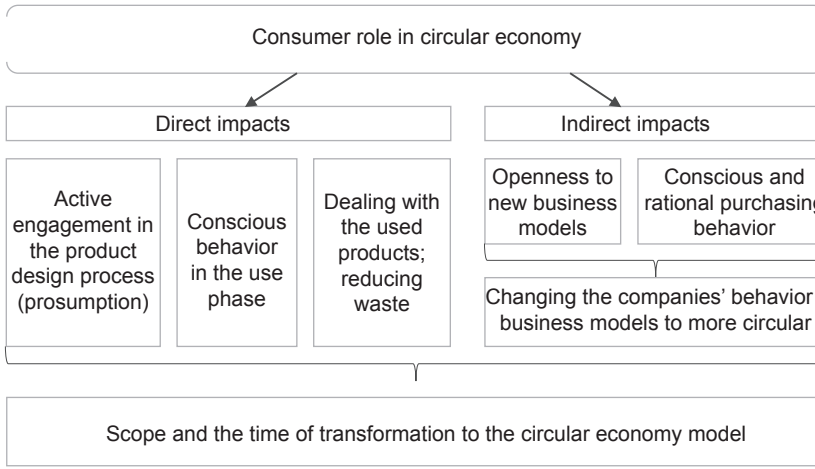

Figure 9.4 Aspects of consumer behavior influencing the scope and the time of the transformation to the circular economy.

2. Openness to cooperation with producers and engagement in design and production (prosumption), using methods such as User Centered Design or Design Thinking (Hannon et al., 2016).
3. Conscious and rational behaviors at the stages of purchasing and using a product: willingness to resist consumerism—deconsumption, rational purchasing, considering ecological aspects while making purchase decisions, appreciating product features such as durability, universality, modularity, repairability, life cycle extension, and recyclability (EllenMacArthurFoundation, 2012).
4. Methods of dealing with used, broken or useless textile and clothing products, as well as willingness to reduce textile waste generated by household (Laitala, 2014).

Some of the abovementioned consumer behaviors will directly influence positive change; these include, e.g., engagement in design and production, manner of use, or dealing with used and useless products.

Other behaviors will exert indirect influence such as consumers' decisions and actions induce changes in companies' behavior, indirectly making them change their business models or their production and distribution strategies (Fig. 9.4).

The following section of the chapter will present the results of my research on the selected aspects of consumer behavior.

9.4 Aim and methods of research

The aim of the research was to analyze the factors which determine consumer behavior in the selected areas relevant for CE; these factors include the following:

- **Proneness to consumerism**, manifesting in behaviors such as purchasing products without a real need, shopping for pleasure, tendency to be tempted by price reductions, purchasing products which are rarely used. Respondents gave an assessment on how typical the

abovementioned behaviors are of them, using a 5-degree scale (1, not at all typical of me; 5, very typical of me)
- **Dealing with used products**; in this respect the following behaviors were studied: household rubbish segregation, repairing broken products and using them until further repair is not possible, giving used products away to friends, family, charities, and making compost heaps from household food leftovers. Respondents assessed the frequency of these actions using a 5-degree ordinal scale (1, never; 2, seldom; 3, sometimes; 4, often; 5, always).
- **Dealing with unnecessary garments**; here a nominal multiple choice scale was used.

In order to establish the factors determining consumer behaviors in the areas relevant for CE, the study analyzed the dependence of behaviors on sociodemographic variables (such as sex, age, education level, financial status, place of residence), and in respect to dealing with useless garments also the dependence on the apparel choice criteria and on respondents' shopping habits.

The study methods applied were cross-tabulation analysis, chi-squared test, Somers' D coefficient, Spearman's Rho coefficient, and Mann−Whitney U test—for two independent samples. In order to divide consumers on the basis of their shopping habits and apparel selection criteria, k-means clustering analysis was applied.

The study on consumerism and dealing with used products was performed in 2015 as part of the project subsidized by the Visegrad Fund, "Prospects of the Visegrad cooperation in promoting a sustainable consumption and production model." It was conducted in four countries: Czechia, Poland, Hungary, and Slovakia, by means of the IMAS Online panel. Two thousand online surveys have been conducted. The sample in each country consisted of the respondents from this country aged 18 years and above (500 surveys per country). The choice of the sample was random-quota based. In the course of selecting samples, the quotas were set for each of the four countries according to the distribution of sex, age, and education level across the country. The request to participate in the survey was sent randomly within particular quotas to ensure that the sample is adequately dispersed, also regionally, and that it fulfils the representativeness conditions. This chapter reports on the results of the study concerning Poland.

The structure of the studied population corresponds to the distributions of sex, age, and education level in Poland (Table 9.2).

The study on dealing with useless garments was conducted on the random sample consisting of 981 Polish adult citizens (in 2010/2011). The surveys were carried out face-to-face by means of computer-assisted personal interviewing. The structure of the studied population is shown in Table 9.3.

9.5 The research results

The analysis demonstrates that Polish consumers declare little identification with the consumerist attitude. The vast majority of respondents (73%) declared that they purchase products only when they really need them. At the same time, only 28% were named as typical behaviors, such as buying for pleasure or buying products they hardly ever use later. A relatively large percentage of Polish consumers admitted that they find

Table 9.2 Sociodemographic structure of Polish respondents (research from 2015)

Gender	Male	50.2
	Female	49.8
Age	18−29 years	26.0
	30−39 years	19.4
	40−49 years	19.0
	50−59 years	20.8
	60+ years	14.8
Education	Primary	6.4
	Vocational	19.6
	Secondary	43.6
	Higher	30.4
Financial situation	I am well off	3.8
	I am pretty well off	28.0
	I am coping	53.6
	I am badly off	9.8
	I am poor	4.8

it difficult to resist price reductions and discounts (Koszewska, 2017) (almost 40% of responders considered such behaviors as typical (Fig. 9.5).

One of the aims of the study was to determine whether these behaviors depend on sociodemographic factors, such as financial situation, education level, age, or sex. The analysis of the distribution of answers and the results of statistic tests demonstrated that the behaviors analyzed depend mostly on the age of respondents. The correlation was relevant for all four questions. The values of the correlation coefficient indicate a weak negative connection between the age and consumerist behaviors (a positive connection concerned only a reversed question about the behavior denying proneness to consumerism: "I buy things only if I really need them"). Elderly people were less prone to consumerist behavior (Table 9.4, Fig. 9.6).

The respondents' level of education proved to have no statistically significant influence on any analyzed behaviors; with respect to financial situation, a statistically significant relation concerned only the tendency to buy for the pleasure of shopping. Somers' D correlation coefficient (−0.12; $P < 0{,}5$) indicates a weak, negative connection between the self-assessment of the financial situation and the tendency to buy for the pleasure of shopping. Respondents who assessed their financial situation as better more frequently admitted the wish to buy for the pleasure of shopping (Fig. 9.7).

The relation between sex and consumerist behaviors was also analyzed; for this purpose, Mann−Whitney U tests were carried out (statistical significance level 5.0%). The

Table 9.3 Sociodemographic structure of Polish respondents (research from 2010/11)

Gender	Male	47.6
	Female	52.4
Age	18–24 years	13.6
	25–34 years	17.4
	35–44 years	14.6
	45–54 years	18.1
	55–64 years	18.1
	65 years and older	18.3
Education	Primary	25.3
	Basic vocational	25.7
	Secondary	33.7
	Higher	15.3
Place of residence	Rural areas	37.6
	Town with population to 20,000	13.9
	20,000–100,000	20.0
	101,000–500,000	15.8
	501,000 and more	12.7

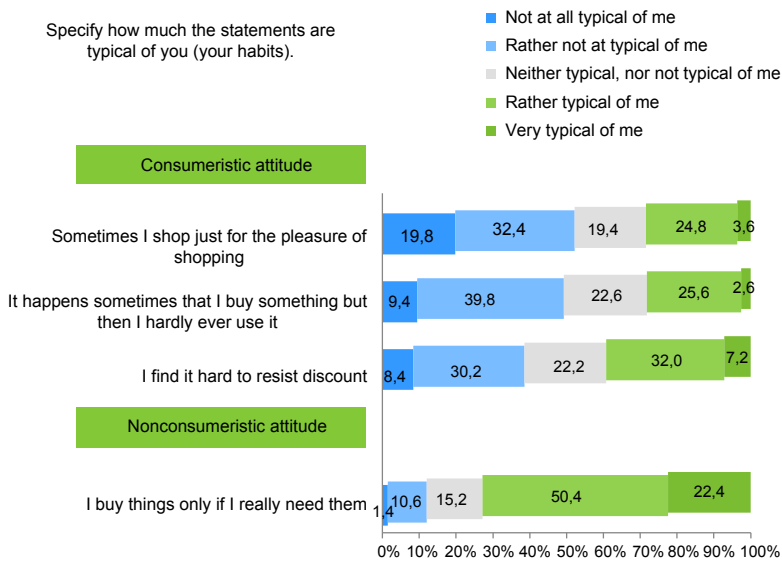

Figure 9.5 Consumerist behaviors of Polish citizens; percentage distribution of answers in 1–5 scale (5, very typical behavior; 1, behavior not typical at all).
From Koszewska, M., 2015. Sustainable Consumption Patterns in Visegrad Region - Polish Report.

Table 9.4 Values of Somers' D and Spearman Rho correlation coefficients which indicate the relation between consumerist behaviors and the age of respondents (statistical significance level $P < .05$)

Consumer behaviors		Somers' D coefficient value	Spearman Rho coefficient value
Consumerist behaviors	Sometimes I shop just for the pleasure of shopping.	−0.141	−0.176
	It happens sometimes that I buy something but then I hardly ever use it	−0.159	−0.206
	I find it hard to resist discount	−0.121	−0.154
Behaviors contradicting consumerism	I buy things only if I really need them	0.158	0.127

Source: Author's calculation by means of IBM SPSS software.

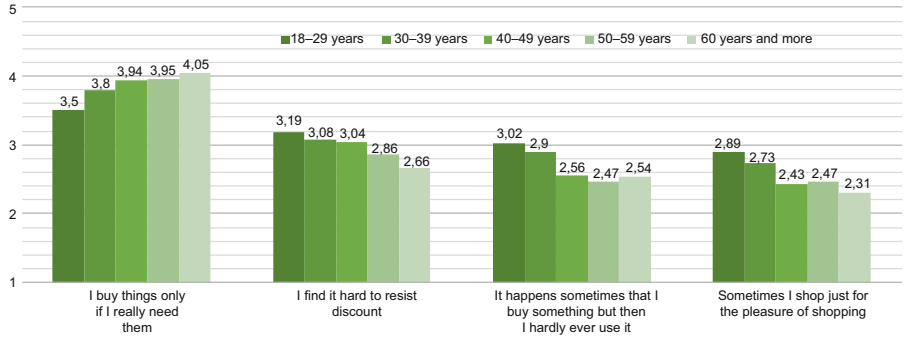

Figure 9.6 Consumerist behaviors of Polish citizens in relation to age—average values (Q) in 1−5 scale (1, behavior very typical; 5, behavior not typical at all).
Source: Author's analysis based on author's study results.

test results did not indicate any statistically significant difference between the behaviors of women and men in the analyzed areas, but the distribution of answers and average rank values suggest that women more often admit that they buy for the pleasure of shopping and find it hard to resist discounts and sales (Table 9.5, Fig. 9.8).

It is worth pointing out that for most questions the percentage of men who did not have an opinion was significantly higher than the percentage of women. This might suggest that shopping as an activity is less important for men and that they do not pay much attention to it (Fig. 9.8).

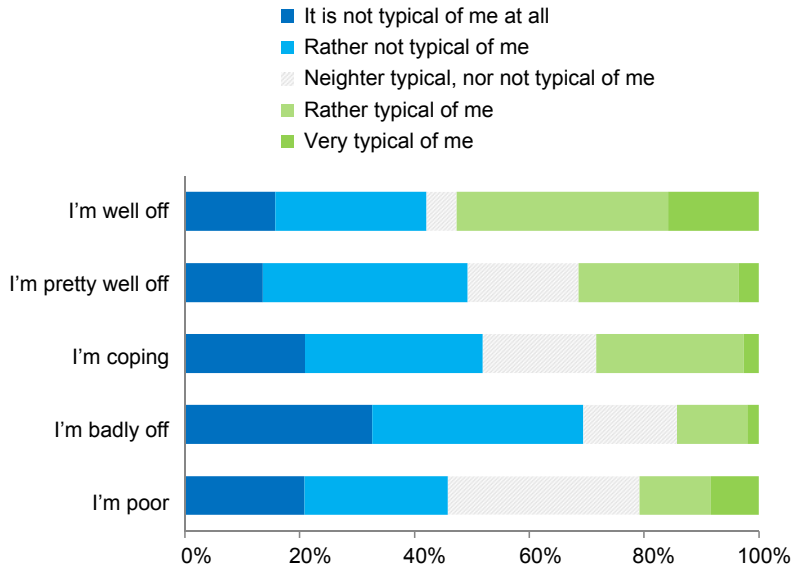

Figure 9.7 Relation between the respondents' self-assessment of their financial situation and the tendency to buy for the pleasure of shopping.
Source: Author's analysis based on author's study results.

Table 9.5 Mann−Whitney U test statistics—diversification of consumerist behaviors among men and women

Question	Sex	N	Average rank	U Mann−Whitney U test statistics
I buy things only if I really need them	Man	251	255.24	30,061 p: 0.426
	Woman	249	245.73	
I find it hard to resist discount	Man	251	243.84	29,577 p: 0.282
	Woman	249	257.22	
It happens sometimes that I buy something but then I hardly ever use it	Man	251	249.3	30,949 p: 0.845
	Woman	249	251.71	
Sometimes I shop just for the pleasure of shopping	Man	251	238.8	28,312 p: 0.06
	Woman	249	262.3	

Source: Author's calculation by means of IBM SPSS software.

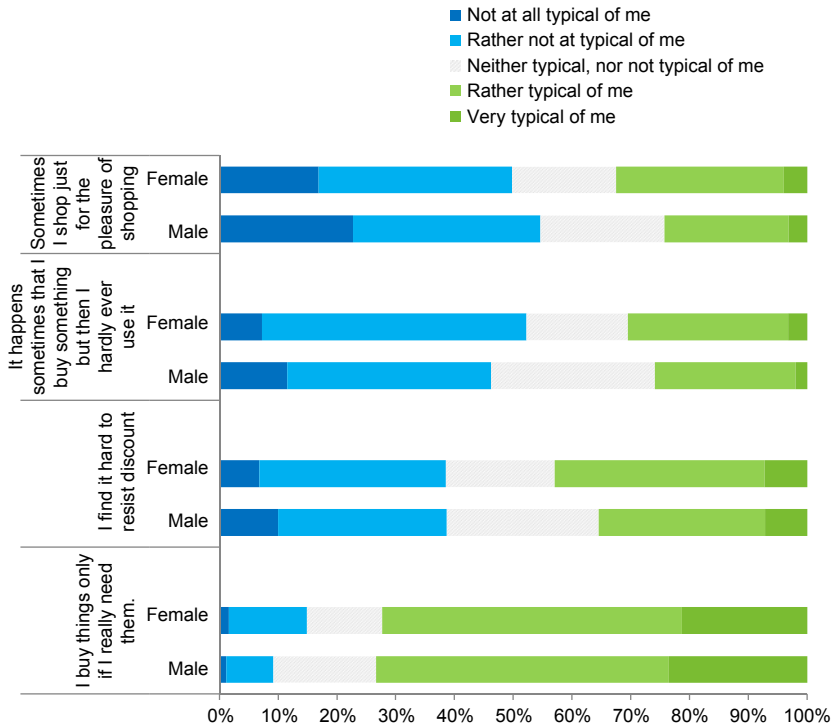

Figure 9.8 Consumerist behaviors in relation to respondents' sex.
Source: Author's analysis based on author's study results.

The second aspect of consumer behaviors relevant for CE is their way of dealing with used products. The vast majority of respondents declared that they always or often segregate household rubbish (78%). It feels encouraging that more than half of the respondents always or often give away used products to family, friends, or charities (60%) and repair broken products (56%), making their life cycle longer. A significantly less frequent activity is making compost heaps from household food leftovers (31% of respondents do it always or often) (Fig. 9.9).

Comparing environmentally friendly prepurchase and postpurchase activities demonstrates that Polish consumers much more often undertake postpurchase activities and the activities which do not demand wide knowledge and engagement, but are familiar and financially rewarding (Koszewska, 2015) (Fig. 9.10).

In this context, it appeared interesting to find out whether the frequency of these activities depends on the respondents' financial situation and on other sociodemographic variables.

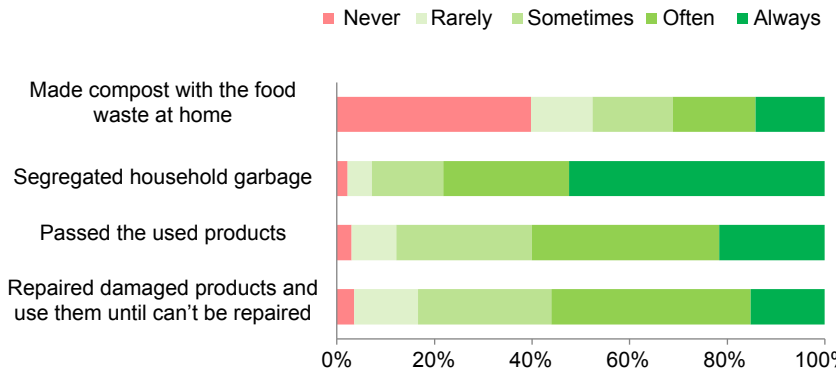

Figure 9.9 Ways of dealing with broken, useless, and used products.
Source: Author's analysis based on author's study results.

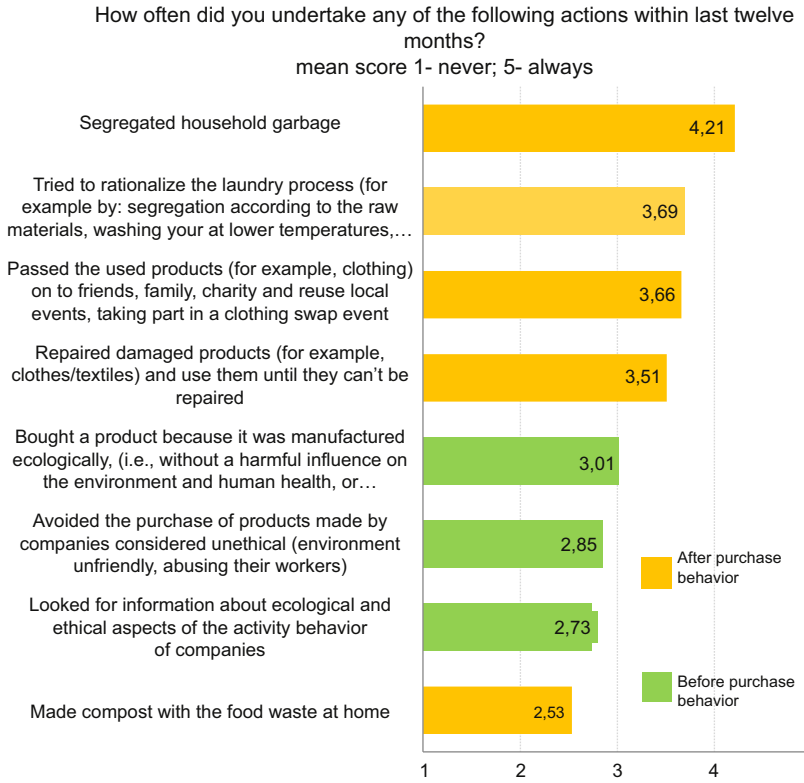

Figure 9.10 Environmentally friendly behaviors of Polish consumers.
From Koszewska, M., 2015. Sustainable Consumption Patterns in Visegrad Region - Polish Report.

Like in the case of consumerist behaviors, the analysis of the distribution of answers and the results of statistic tests demonstrated that the way of dealing with used/useless products depends more on the respondents' age, but also in this case this relation did not concern all analyzed behaviors. The connection was relevant for household rubbish segregation and for giving away used/useless products to friends, families, charities, etc. In both cases, the values of correlation coefficients indicated a positive connection between the age and the frequency of analyzed behaviors. Elderly people segregated rubbish and gave away useless products more often than younger people (Table 9.6, Fig. 9.11). It is quite surprising, however, that there is no statistically significant relation between the age of respondents and the frequency of repairing broken products. It would appear that elderly people are more inclined, and better skilled, to repair products.

Table 9.6 Values of Somers' D and Spearman Rho correlation coefficients which indicate the relation between the age of respondents and the frequency of segregating rubbish and giving away useless products (statistical significance level $P < .05$)

Consumer behaviors	Somers' D coefficient value	Spearman Rho coefficient value
Household rubbish segregation	0.2	0.27
Giving away used products to family, friends, and charities	0.09	0.12

Source: Author's calculation by means of IBM SPSS software.

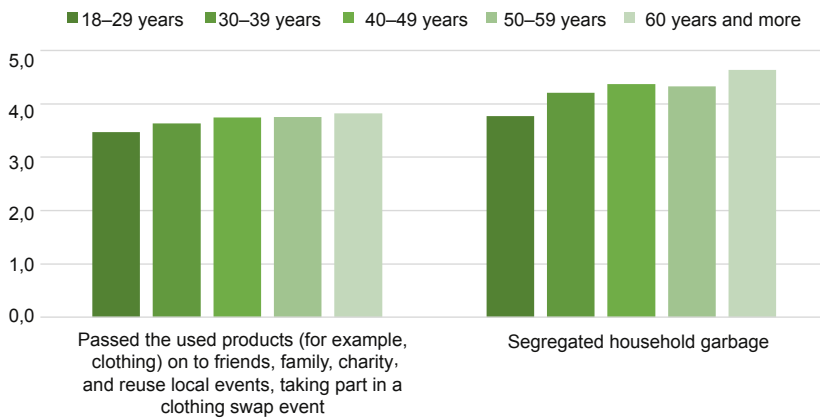

Figure 9.11 Relation between age and rubbish segregation/giving useless products away. Source: Author's analysis based on author's study results.

Education level was significantly related only to the frequency of rubbish segregation. The value of Somers' D correlation coefficient (0.2; $P < .005$) indicates a weak positive relation between education level and rubbish segregation. The better educated a person, the higher the declared frequency of rubbish segregation (Table 9.7, Fig. 9.12).

The study also analyzed different ways of dealing with used/useless products in relation to the respondents' sex. For this purpose, a Mann−Whitney U test was carried out (statistical significance level 5.0%). The test results indicated a statistically significant difference between the behaviors of women and men with respect to giving away used/useless products to family, friends, and charities. Women displayed such behaviors significantly more often than men (Fig. 9.13).

As the results of the survey about dealing with useless clothes demonstrated, Polish consumers declare that they act quite responsibly in this respect. The vast majority (over 60%) declares that they give clothes away to family, friends, or charities (e.g., Polish Red Cross), while 16% of respondents keep used clothes at home and only 8% throw them in the trash. Behaviors declared by respondents allow to conclude that most garments which are no longer useful remain in circulation for some time, which is favorable (Fig. 19.14).

Table 9.7 Mann−Whitney U test statistics—diversification of consumerist behaviors among men and women in relation to extending a product's life cycle

Behavior	Sex	N	Average rank	U Mann−Whitney U test statistics
Giving away used/useless products	Man	251	230.68	26273.5 p: 0.001
	Woman	249	270.48	

Source: Author's calculation by means of IBM SPSS software.

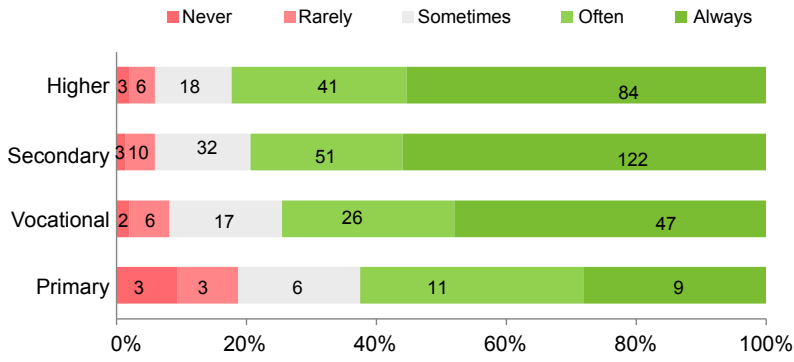

Figure 9.12 Relation between rubbish segregation and education level.
Source: Author's analysis based on author's study results.

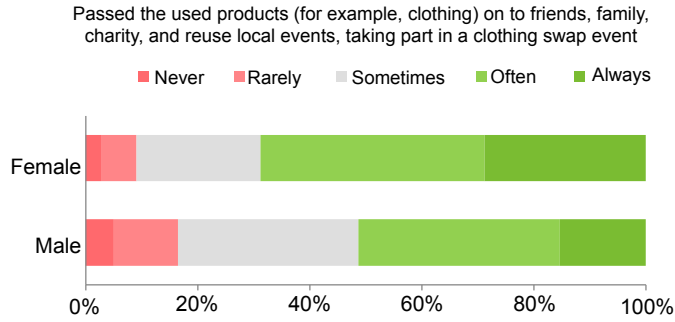

Figure 9.13 Relation between sex and giving away used/useless products to family, friends, and charities.
Source: Author's analysis based on author's study results.

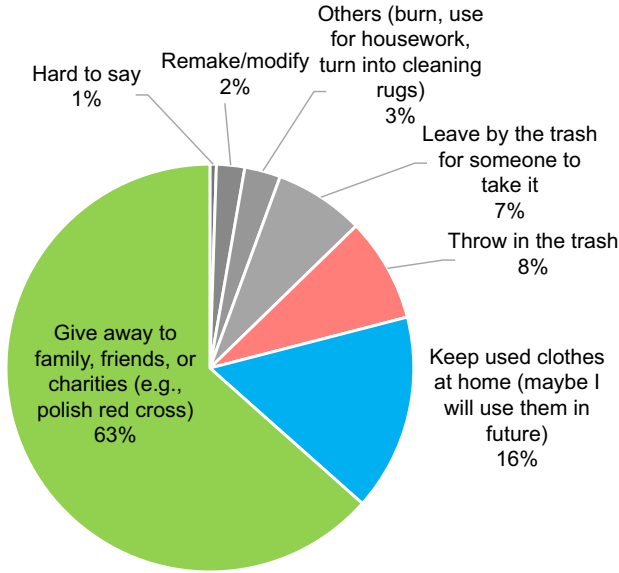

Figure 9.14 Ways of dealing with garments which the respondents are no longer going to wear.
Source: Author's calculation by means of IBM SPSS software.

The analysis of the distribution of answers as well as the results of the chi-squared test ($P < 0.05$) demonstrated that the ways of dealing with used garments depend on the respondents' sex, education level, and place of residence, but do not have a statistically significant relation to their age. Women gave useless clothes away to friends, family, or charities much more often than men did. At the same time, women less frequently threw useless clothes in the trash (Fig. 9.15).

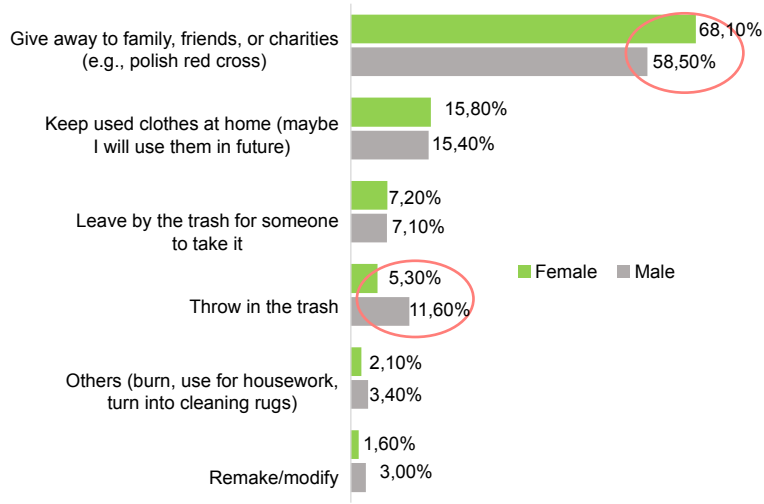

Figure 9.15 Ways of dealing with garments which the respondents are no longer going to wear in relation to the respondents' sex.
Source: Author's calculation by means of IBM SPSS software.

People with higher education significantly often threw less useless clothes in the trash and more often gave it away to family, friends, or charities (Table 9.8, Fig. 9.16).

Residents of rural regions less often than residents of big cities threw useless clothes in the trash, kept them with the intention of using them in the future, and altered them, while they less often gave the clothes away to friends or threw them into the Polish Red Cross collection bins (Table 9.9).

The results of the chi-squared test did not, however, allow to corroborate the hypothesis that there is a statistically significant relation between the way of dealing with useless clothes and the respondents' age. Nonetheless, the analysis of the distribution of answers allows to conclude that elderly people (65+) more often than other age groups kept useless clothes with the intention of wearing them or altered them. They less often gave them away to friends, family, or charities (Table 9.10).

In order to assess the influence of shopping habits and apparel selection criteria on the ways of dealing with useless clothes, the study analyzed the variability of those behaviors in the selected typological groups, described in detail in (Koszewska, 2013). Fig. 9.17 shows the characteristics and the share of particular typological groups in the population studied.

Both the results of the chi-squared test ($P < .005$) and the analysis of distribution of answers demonstrated that the ways of dealing with clothes no longer used depend on the consumers' shopping habits and their apparel selection criteria (Fig. 9.18).

The groups for which ecology and ethics are secondary at the stage of purchasing clothes more often declared the behaviors less desired for CE, such as throwing

Table 9.8 Ways of dealing with garments which the respondents are no longer going to wear in relation to education level

	Education				Total
	Primary	Vocational	Secondary	Higher	
Other (I incinerate them, I use them for household working clothes, I use them as a cleaning cloth)[a]	8.4	10.7	11.5	7.7	9.9
I give them away, e.g., to country people, I throw them into Polish Red Cross collection bins, etc.	53.8	59.3	67.1	77.5	63.3
I keep them because I might wear them yet	17.7	18.6	15.4	7.9	15.7
I convert them	5.6	1.2	0.9	1.3	2.2
I throw them into the trash	13.7	9.5	5.1	4.6	8.3
Hard to say	0.8	0.8	0.0	0.7	0.5

[a]Most frequent answers: I incinerate them, I use them for household working clothes, I use them as a cleaning cloth.
Source: Author's calculation by means of IBM SPSS software.

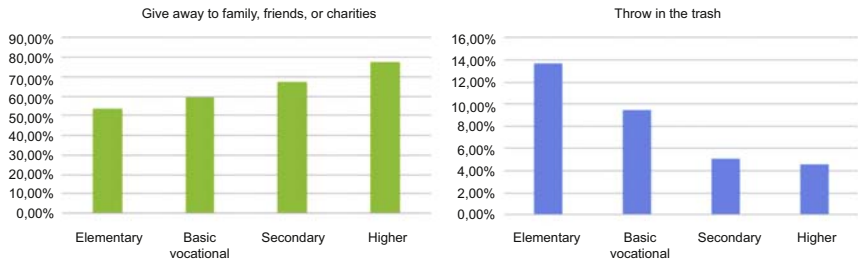

Figure 9.16 Ways of dealing with garments which the respondents are no longer going to wear in relation to education level.
Source: Author's calculation by means of IBM SPSS software.

useless clothes in the trash or keeping them at home. They less often gave these clothes away to the needy or to the organizations which deal with the utilization of garments.

The analysis of answers to the question about altering useless clothes may lead to interesting conclusions. This option was significantly more often chosen by a group of thrifty consumers, which might indicate that the decision to alter clothes to continue using them results not from knowledge and ecological awareness but from economic reasons.

Table 9.9 Ways of dealing with garments which the respondents are no longer going to wear in relation to place of residence [%]

	Rural regions	Town below 20,000 inhabitants	20,000–100,000 inhabitants	101,000–500,000 inhabitants	501,000 and more inhabitants	Total
I leave them by a dustbin for somebody to take	4.3	3.6	10.7	9.7	11.3	7.2
I give them away, e.g., to country people, I throw them into Polish Red Cross collection bins, etc.	49.6	70.8	67.3	76.8	73.4	63.4
I keep them because I might wear them yet	22.8	16.8	10.7	8.4	8.9	15.5
I alter them	4.1	1.5	0.5	0.6	2.4	2.2
I throw them into the trash	13.0	6.6	8.2	4.5	1.6	8.4
Other[a]	4.9	0.7	2.6	0.0	2.4	2.8
Hard to say	1.4	0.0	0.0	0.0	0.0	0.5

[a]Most frequent answers: I incinerate them, I use them for household working clothes, I use them for cleaning cloth.
Source: Author's calculation by means of IBM SPSS software.

Table 9.10 Ways of dealing with garments which the respondents are no longer going to wear in relation to age [%]

	18–24	25–34	35–44	45–54	55–64	65 or more	Total
I leave them by a dustbin for somebody to take	3.8	7.6	7.0	7.9	8.5	6.1	6.9
I give them away, e.g., to country people, I throw them into Polish Red Cross collection bins, etc.	64.7	65.9	69.9	61.6	66.7	53.9	63.5
I keep them beca use I might wear them yet	17.3	17.1	12.6	13.6	13.0	20.0	15.6
I alter them	1.5	2.9	0.0	3.4	0.6	4.4	2.2
I throw them into the trash	9.8	4.7	8.4	9.0	8.5	10.0	8.4
Other[a]	3.0	1.2	2.1	4.5	1.7	4.4	2.9
Hard to say	0.0	0.6	0.0	0.0	1.1	1.1	0.5

[a]Most frequent answers: I incinerate them, I use them for household working clothes, I use them as a cleaning cloth, I sell them.
Source: Author's calculation by means of IBM SPSS software.

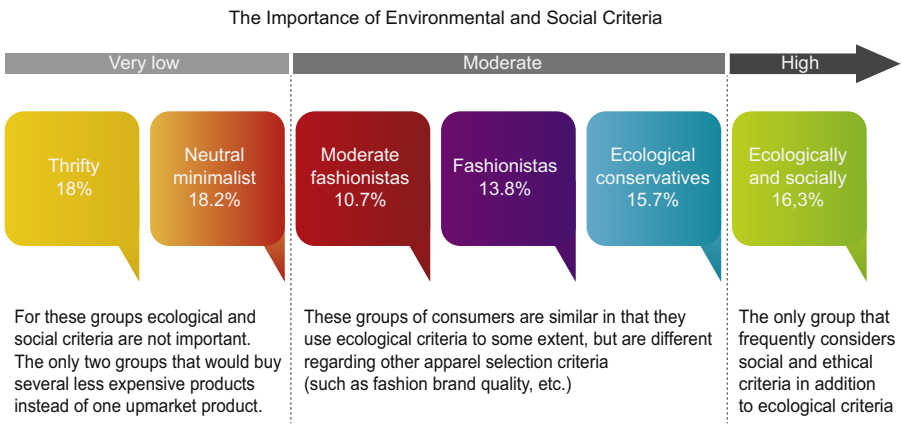

Figure 9.17 The typology of consumers based on apparel selection criteria and buying habits. Based on own research. The precise characteristic of consumer types in: Koszewska, M., 2013. A typology of Polish consumers and their behaviours in the market for sustainable textiles and clothing. International Journal of Consumer Studies 37 (5), 507–521.

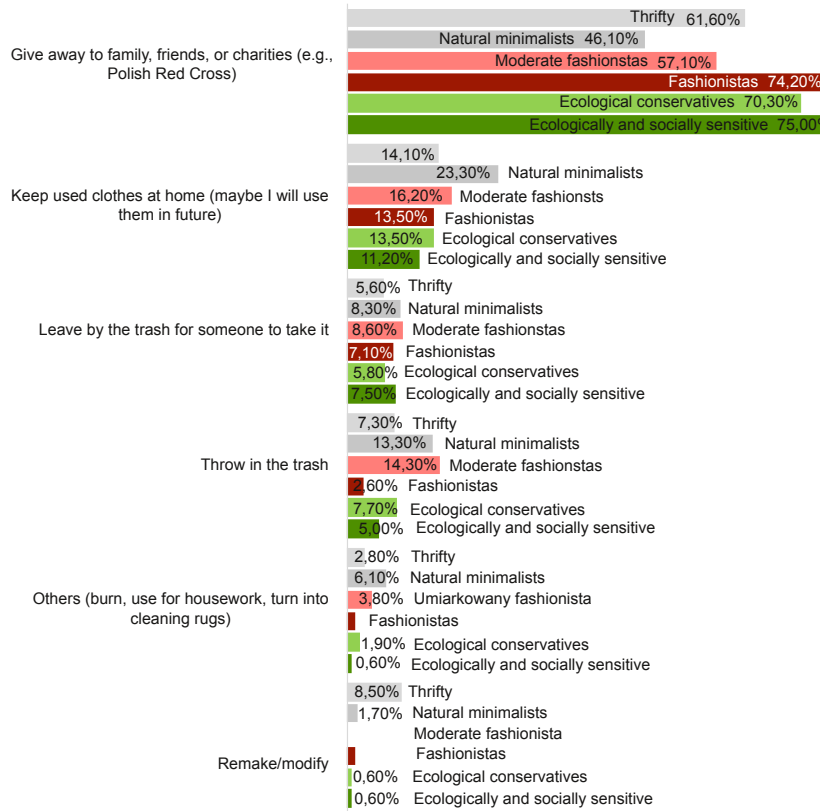

Figure 9.18 Variability of behaviors with respect to ways of dealing with useless clothes in selected typological groups.
Source: Author's calculation by means of IBM SPSS software.

9.6 Conclusions

The analysis demonstrates that Polish consumers declare little identification with the consumerist attitude, and that such behaviors depend mostly on the age of respondents, and not on sex, education level, or financial situation. Elderly people were less prone to behaviors such as shopping for pleasure, buying on impulse (discounts and sales), or buying products they do not later use.

The respondents' level of education proved to have no statistically significant influence on any analyzed behaviors; with respect to financial situation, a statistically significant relation concerned only the tendency to buy for the pleasure of shopping. Respondents who assessed their financial situation as better more frequently admitted the wish to buy for the pleasure of shopping.

Comparing environmentally friendly prepurchase and postpurchase activities demonstrate that Polish consumers much more often undertake postpurchase activities and the activities which do not demand wide knowledge and engagement, but are familiar and financially rewarding. The vast majority of the respondents declared that they always or often segregate household rubbish and more than half declared that they always or often give away used products to family, friends, or charities and repair broken products, making their life cycle longer. Like in the case of consumerist behaviors, the variable which most strongly determined the way of dealing with used products was the respondents' age, but also this relation did not concern all analyzed behaviors. Elderly people segregated rubbish and gave away useless products more often than younger people did. Education level was significantly related only to the frequency of rubbish segregation. The better educated a person, the higher the declared frequency of rubbish segregation.

The study concerning a particular product group, i.e., clothes, demonstrated that the way of dealing with useless clothes was significantly dependent on sociodemographic variables, such as sex, education level, and place of residence. In this case, age was slightly less important, but the analysis showed that elderly people (65+) more often than other age groups kept useless clothes with the intention of wearing it or altered them. The study also confirmed that the ways of dealing with useless clothes are significantly determined by previous shopping habits and by apparel selection criteria.

Taking into consideration the results of both conducted studies, it can be concluded that sociodemographic variables significantly determine consumer behaviors concerning CE, but the manner and range of this influence can vary according to a particular aspect of consumer behavior, as well as according to a product group.

It should be generally emphasized, however, that at the moment there is a limited number of comprehensive studies on consumer behavior related to the implementation of CE. The studies available are based only on selected aspects of behavior, like disposal practices (Constanza, 2012; Joung and Park-Poaps, 2013; Laitala, 2014; Weber et al., 2017), purchasing behavior (Gwozdz et al., 2017; Wang et al., 2014), and business models (Gullstrand Edbring et al., 2016); they embrace only part of population or they are not up to date.

The analysis undertaken in this chapter also has some limitations: the survey was conducted on two different groups of cnsumers in two different times and it embraced only some selected aspects of consumer behavior relevanot for CE. Moreover, it has to be noted that the study concerned consumer behavior in Poland, a country which, first, has only recently (compared with Western Europe) started to follow the trends of consumerist behaviors, such as fast-fashion, and, second, has yet to match the level of knowledge, ecological awareness, and environmental movement activity of those countries (Koszewska, 2011b).

Therefore, in order to confirm the results achieved or to identify potential differences between countries from various regions, it would be advised to repeat the study on a larger scale and to cover all aspects of consumer behavior relevant for CE.

References

Agrawal, Y., Barhanpurka, S., Joshi, A., 2013. 'Recycle Textiles Waste', Textile Review.
Constanza, B., 2012. Consumer clothing disposal behaviour: a comparative study. International Journal of Consumer Studies 36 (3), 335−341.
EC, 2018. Textiles and Clothing in the EU. European Commission. https://ec.europa.eu/growth/sectors/fashion/textiles-clothing/eu_en.
EllenMacArthurFoundation, 2012. Towards the Circular Economy. Economic and Business Rationale for an Accelerated Transition. The Ellen MacArthur Foundation.
EllenMacArthurFoundation, 2013. Towards the Circular Economy. Economic and Business Rationale for an Accelerated Transition. The Ellen MacArthur Foundation.
EllenMacArthurFoundation, 2015. Delivering the Circular Economy, a Toolkit for Policymakers. Ellen MacArthur Foundation.
Fletcher, K., 2007. 'Slow Fashion', Ecologist.
Gullstrand Edbring, E., Lehner, M., Mont, O., 2016. Exploring consumer attitudes to alternative models of consumption: motivations and barriers. Journal of Cleaner Production 123, 5−15.
Gwozdz, W., Nielsen, K.S., Müller, T., 2017. An environmental perspective on clothing consumption: consumer segments and their behavioral patterns. Sustainability 9 (5), 1−27.
Hannon, E., Kuhlmann, M., Thaidigsmann, B., 2016. Developing products for a circular economy. In: Cross-functional Collaboration and Customer-focused Design Thinking Can Help Companies Reap More Value from the Energy and Resources They Use. McKinsey & Company.
Joung, H.-M., Park-Poaps, H., 2013. Factors motivating and influencing clothing disposal behaviours. International Journal of Consumer Studies 37 (1), 105−111.
Koszewska, M., 2011a. Social and eco-labelling of textile and clothing goods as means of communication and product differentiation. Fibres and Textiles in Eastern Europe 19 (4), 20−26.
Koszewska, M., 2011b. The ecological and ethical consumption development prospects in Poland compared with the Western European countries. Comparative Economic Research 14 (2), 101−123.
Koszewska, M., 2013. A typology of Polish consumers and their behaviours in the market for sustainable textiles and clothing. International Journal of Consumer Studies 37 (5), 507−521.
Koszewska, M., 2015. Sustainable Consumption Patterns in Visegrad Region - Polish Report.
Koszewska, M., 2017. Rola konsumenta w tworzeniu gospodarki o obiegu zamknietym. In: Salerno-Kochan, R., Wojnarowska, M. (Eds.), Towaroznawstwo w Badaniach i Praktyce − Ekologiczne, Ekonomiczno-prawne i Marketingowe Aspekty Jakości Produktów. Polskie Towarzystwo Towaroznawcze, Kraków.
Laitala, K., 2014. Consumers' clothing disposal behaviour − a synthesis of research results. International Journal of Consumer Studies 38 (5), 444−457.
Lewandowski, M., 2016. Designing the business models for circular economy−towards the conceptual framework. Sustainability 8 (1), 1−28.
OECD, 2011. Perspectives on Global Development 2012: Social Cohesion in a Shifting World. OECD Publishing.
OLIVER_WYMAN, 2015. Fast Fashion. Staying on-Trend with a New Style of Supply Chain. OLIVER WYMAN.

Remy, N., Speelman, E., Swartz, S., 2016. Style That's Sustainable: A New Fast-Fashion Formula. McKinsey & Company.

Resta, B., Gaiardelli, P., Pinto, R., Dotti, S., 2016. Enhancing environmental management in the textile sector: an Organisational-Life Cycle Assessment approach. Journal of Cleaner Production 135, 620−632.

Sempruch-Krzemińska, K., 2014. Fast fashion — przyszłość branży mody? Fast fashion — future of fashion industry? Marketing i Rynek (2), 25−31.

UNFPA, 2017. World Population Dashboard. United Nations Population Fund.

Wang, P., Liu, Q., Qi, Y., 2014. Factors influencing sustainable consumption behaviors: a survey of the rural residents in China. Journal of Cleaner Production 63 (0), 152−165.

Weber, S., Lynes, J., Young, S.B., 2017. Fashion interest as a driver for consumer textile waste management: reuse, recycle or disposal. International Journal of Consumer Studies 41 (2), 207−215.

Future for circular economy

10

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10.1 Introduction

Textile and clothing industries are establishing high sustainable growth among various industries and seemingly various challenges to sustain the performance level. The rise of population and huge utilization of products lead to the requirement of textiles, design, process, and resources. Various studies incorporated and identified to obtain circular material loops in case of construction or manufacturing and formulation and evaluated the accessible directions for the recovery process. Over the last few years, the thought toward a circular economy (CE) is rising in different fields like science, consultancy, industries, and so on. It is a new industrial concept intended to reuse the resources or disposal of waste (Gallaud and Laperche, 2009). The principles of the CE are established in several thoughts like industrial ecology and so on. Depending on the renewable energy and energy savings, CE asserts complex system operations such as recovery, repair, and remanufacturing of products for an industrial economy (Singh and Ordonez, 2016). The major advancement in the CE is that within the same product, the accumulation and extraction of recovered materials have been carried out. Some of the origins establish the circular business model with operations like recycling, reusing, recovering, redistributing, manufacturing, etc. To integrate the ecological systems and financial growth, the CE has reached a notable fact in several industries. In order to reduce waste and to avoid negative environmental impact, more and more CE needs to be incorporated. It is a sort of revising the relationships between markets, customers, and natural assets. It is one of the core elements endorsed by several industries for their growth. The CE is a general phrase for an economy where it is disconnected from limited source use. CE and its effects on the policies and regulations is one of the pertinent problems to the textile and fashion industry. The installment of fashion industries is more useful; fast fashion has become one of the major concerns in environmental impact and sustainability. Hence interest toward green products is rising due to the abovementioned controversies (Todeschini et al., 2017) The idea regarding the CE has been everywhere for a couple of decades. In case of business, it helps to convert waste into wealth (Lacy and Rutqvist, 2015). The CE is against the straight model of asset utilization depending on the usage and disposal of waste. Over last 150 years, the development of industries has been governed by the linear model in which sources are separated from the resource-rich countries and results obtained from the enriched countries (Franco, 2017). Then the end user removes those products and displaces them with contemporary products. The general

Circular Economy in Textiles and Apparel. https://doi.org/10.1016/B978-0-08-102630-4.00010-8

model is particularly based on "take make dispose of" in that benefits are obtained by manufacturing products (Pitt and Heinemeyer, 2015).

Various industries have noticed that the risks are associated with the linear model due to restrictions to supply the products and the high cost of resources. Hence the CE plays a major role in finding a solution to objections related to financial development and sustainability. The linear system is based on production and consumption and it is reaching its end process (Ghisellini et al., 2016). This type of linear system is running out because it is bringing out financial concerns. Additionally, it is also bringing out the damage to the environment due to the waste associated with the textile and fashion industry and then due to the reason of climate change and pollution. Some of the studies concluded that the linear system is not capable of providing the sustainability and proper living environment for humans and other living species (Ghisellini et al., 2016). Therefore, nowadays researchers are focused on finding a solution through certain actions like mapping and reducing firms to solve this concern which creates a hazard to the surroundings (Lozano et al., 2014). Life cycle assessment, low exhaust, and efficiency are the major considerations to avoid the environmental issues related to the abovementioned concerns. These concepts utilize fewer resources, give low emissions, and are more efficient. Initially, the resources are separated, then create a product using extracted resources, and then finally undergo treatment like a landfill. The major downside of the linear approach is the disposal of waste at the end of the cycle; nevertheless, these concepts provide efficiency by reducing the toxicity and low utilization of resource material. Although these actions have certain advantages than the linear approach, less usage of resource soon reaches its stage limit. It can provide only a short-term solution to the available issues. Higher sustainability can be obtained only in principle of CE. A pictorial representation of material flow in the linear and circular approaches are represented in Fig. 10.1(a) and (b).

The CE is also referred to as an industrial economy because it is generally known that regeneration is carried out by intention and design. The analysis regarding the CE is reaching the implementation level (Lieder and Rashid, 2016). There are different methodologies and exercises regarding the utilization of CE, and these change as indicated by the definitions and nations being considered. Creating a CE has become of major importance in various businesses and cities to shift over sustainability, but it is an expansive concept. According to the CE action plan, various industries are changing into new intentions like the reuse of the retrieved product. Textile and fashion industries are establishing these efforts which were named as "circular fashion."

In order to enhance the CE, several fundamentals are needed. It advances the utilization of products with characteristic segments called "nutriments" that can be reabsorbed into the biosphere without any destruction in addition to recycling and reuse of products, which are not appropriate for the biosphere. The last utilization of product should be in a CE that depends on the "functional service economy." Various advantages are available for achieving CE because most of the positive effects like the easy supply of raw materials, higher cooperation with the customers, simple product

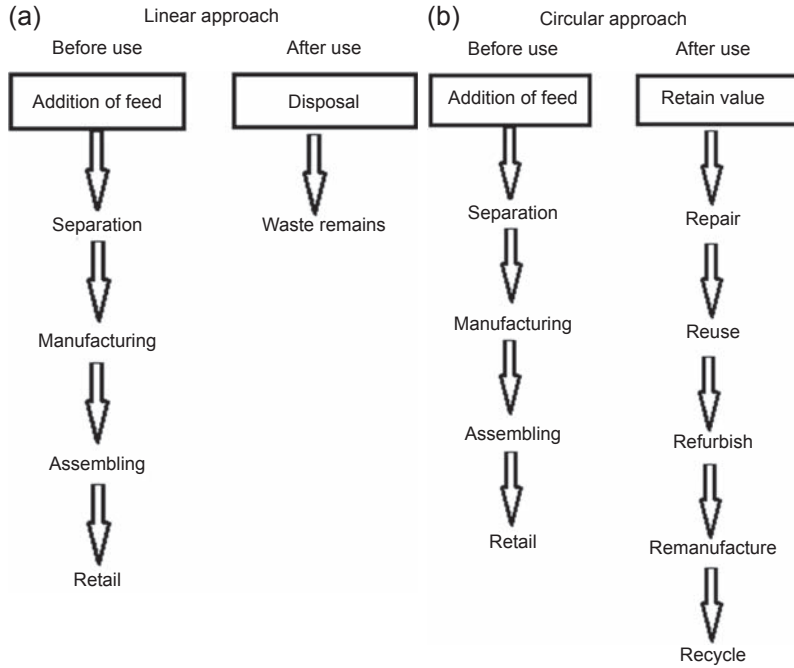

Figure 10.1 (a) Material flow in the linear approach. (b) Material flow in the circular approach.

design, and uncomplicated handle of the life cycle of products are obtained through the generalization of the CE. CE comes under industrial economy for improving the sustainability of industries through design. The waste generated in the first cycle can be utilized as feed for the next cycle in the generation of new product, which is the objective of the CE (Tukker, 2013). Today, CE has been embraced as a controlling standard in numerous nations' strategies, which have moved toward its execution in various ways. While China has embraced a best down approach, different nations have upheld CE advancement with base up arrangements. CE is characterized by European Institutions as an economy "where the estimation of items, materials and assets is kept up in the economy for whatever length of time that conceivable, and the age of waste limited." This chapter explores the CE in textiles and fashions, which is used to conclude future trends. In addition, it targets how the CE will lead the fashion and textile industry to a sustainable future. A more detailed explanation about the obstacles involved in CE have been described in barriers in CE. The next section depicts the universal employed in CE. Then the remaining sections explains briefly about the steps for obtaining the CE which is used to represent the success relevance to CE.

10.2 Barriers for CE

The adaption under the CE by the some of the politicians, scholars, or organizations is still under progress due to less framework. The changeover toward a new model can enhance the social and economic complications in the industries. The technical barriers include some of the factors like availability of adequate technology and so on. This barrier is one of the major issues related to the CE. There is a development of a technological gap, and lack of well-educated and trained people are generated due to technical barriers. The higher trends in the CE and sharing economy are the most important assets in case of developing new business models by seeing sustainability as a design element. The innovations in the fashion industry and its production process facilitate to determine the new model. Due to the changeover from a linear economy to CE, the linear approach develops institutional barriers (Fischer and Pascucci, 2017). The shifting process needs some of the rules which are required for the CE basis. Most organizations are involved in the certain firm collaborations that are basically based on complexities, so the changeover may create new regulations in order to detect sustainable results. Remanufacturing of fashion helps to obtain the CE because it is adequate to some of the consumers. Although it has certain disadvantages like remanufacture, fashion can only give the best design, but not the standard fabric for the retailer. And hence retailers are not ready to pick the remanufactured fashion due to their nonstandard fabric. The accompanying segments introduce some of the hindrances and challenges that may keep the CE in textiles and fashion from successfully being carried out. The industries must know the complexities available in the degradation process, the toxicity of subproducts, etc. Sometimes the physical properties of the waste make it impossible to implement the CE. And also the physical state may be unsuitable for the remanufacturing process. In order to obtain the desired quality or specific property, the additives were added during the remanufacturing process. So it is required to maintain its properties during the recycling process. Eventually, some materials cannot be recycled because it was designed in such a way that poses various problems and financial crisis that it will generate for the companies. The recycling of textile waste also creates another issue like economical barriers. Conversion of waste into a new material requires some new accompaniments which need to be maintained properly. To operate the equipment, qualified persons and training are necessary to establish a sustainable development through the CE. The information regarding the remanufacturing and recycling of waste needs to be translated to another person properly and disseminated because the circulation of information in the industries can be slowed down. Stakeholders do not trust some of the people, and they keep the information like balance sheet, manufacturing protocol, and so on a secret. This creates difficulty in establishing a successful CE. The most important barriers are inappropriate technology, lag of design, low encouragement and support, high capital cost and transaction costs, lack of framework, undesired profit, etc.

10.3 Global trends—circular economy

The trends behind the CE are to bring out the product generation based on restoration and regeneration. The main objective of the CE is to manage all products and their resources and to consider their value at all times. They are developed to combine growth and development from the utilization of limited resources. It is highly focused on design and optimization and the maintenance of resources, creation of business models, establishment of a framework and building blocks for a tough system (Webster, 2015). The abovementioned facts can be used to produce a high life span product and facilitate restoration. Generally, the textile industry is considered as a polluting industry due to its waste which is adding to the pollution on the environment and this is the reason for the huge consumption of resources. The textile industries are using two resources for their production: one is cotton and the other is polyester. The usage of this material is increased and leads to fast fashion that influenced the development of low-cost product and garments. The selling of high volumes of the low-cost product is taking place, particularly in low-wage countries so that the generation of waste and fast fashion comes under the environmental issues. To attract the consumers, the garments are focused on fast fashion and bringing out new collections and designs. Most of the textile waste is generated from countries like the Netherlands and the United Kingdom, which is about 61% and finally reaching the landfill process. Of the textile waste collected from these countries, only 84% are reused and the remaining 16% only undergoes a recycling process. Asian countries like Japan and China were the first that established the CE properly to other countries. Many European countries have initiated the policies and regulations based on the CE, but Germany and Denmark play a vital role in the implementation. The principle of CE is imitated from environmental economics, industrial ecology, and so on (Preston, 2012). Most of the industries are concentrated on their growth by not depending on separation and absorption of earth's resources and without misusing energy. Various researchers have studied about the CE and their disciplines, which include circular product design, remaking of products, industrial ecology, circular business models, and so on (Bakker et al., 2014; Bocken et al., 2014; Souza, 2013). Different definitions have been described by researchers which explain that CE is designed eagerly to make and enhance sustainability. The waste can be twisted into a more valuable resource, which can be accomplished only in the CE than the linear economy. It is the protocol established in the EU in 2015 in order to bring out the sustainable development (Malinauskaite et al., 2017). An interest toward CE at a national and international level has been raised. The changeover toward CE aids the entire modification of the system. High usage of consumer goods is taking place in the textile and clothing or fashion industry of about more than 37%, particularly in European countries. The types of sectors involved are clothing, technical textiles, and interior textiles, and they are described by the complicated and elongated supply chain. Among the universe textile and fashion industry is decided as one of the most highly creating pollution against the

environment and disputing industries (Bostrom and Micheletti, 2016). Based on the challenges, certain studies were focused on some of the problems like noncurable materials, utilization of water, and toxic chemicals use (Resta et al., 2016). The CE plays a vital role in reducing waste by expanding the network toward fashion resources. The present linear models are used only for a short period of time and not sustainable and hence there is a need to move close to CEs which bring out the low environmental impacts in textiles available in garments. Additionally, there is a finite supply of resources and minimal landfill process. In 1975, the European Union popularized its waste grouping and was affiliated by various countries in order to bring out guidelines regarding the waste sectors (Williams, 2015) and different enhancements have been made to locate the water issues. The circular in European countries enhanced the priorities toward jogs, investment, climate, and industrialization. They have adapted an action plan which includes areas like production, marketing, consumption, innovation, investment, and monitoring. Some of the states and regions are recommended to develop action plans in areas like England, Scotland, Denmark, and the Netherlands (Whicher et al., 2018). The action plans were strongly stressed on the design of CE. Finally, CE has been introduced in several industrial economies and put forward to transform the current linear model into the circular model to save the resources from waste (Stahel, 2013). The main intention is to create results for the CE and provide consideration toward the environmental footprint of wasted clothes. Various substantial economies have initiated their sustainability reports and regulations regarding the CE. It acts as a different model of production and consumption and hence affording to sustainable development (Geissdoerfer et al., 2017).

10.4 Market for circular economy

The CE helps to move away from the linear approach toward a regenerative economy. Due to the introductory given by China and the European Union, the CE becomes highly well known, which will make countries to minimize environmental pollution. The shift of CE enables to get the valued products from the waste and resolve the needs of our surroundings. The CE shows its interest in the design, establishing less environmental impact, utilization of renewable energy resources, raising product durability, and reusing and recovering of materials. It stimulates the economic development through the recycling process, reducing waste and the cost of the product and also lowering the environmental impacts. The CE provides an alternate fact to the already available concepts like cradle to cradle (C2C) or closed loop economy (Kama, 2015), spaceman economy, industrial ecology, steady-state economy, and performance economy. But the growth of the CE has been increasing worldwide. The main intention of the CE is to prevent waste. Through some design strategies, resource optimization can be carried out in the CE approach. Recycling and reusing of waste acquired after the completion of one life cycle is a CE (Pomponi and Moncaster, 2017). Usually, two types of chain are followed in industries: linear and circular loop chain. In the CE concept, all the waste is collected and then remanufactured and reused. It is one of

the concepts which mainly focuses on the optimization of natural resources and reduction of waste. Remanufacturing also comes under the CE, which gives an assurance on the efficiency of the remanufactured product. The repairing process is also carried out in the CE (Lewandowski, 2016; Lieder and Rashid, 2016). At last, the manufacturers refurbish the products with the same standards, and customers get the refurbished products from the manufacturers. And hence the CE prevents the waste generated from the previous cycle to create a sustainable development. In the eradication of waste, usage of biological materials and dependence on renewable energy are the principles which are utilized by the CE. The concepts behind the CE are C2C and eco-effectiveness (Braungart et al., 2007; Ghisellini et al., 2016). This C2C is not the concept of reducing the waste, it is a designing process of products and a process to make waste undergo the biological treatment like landfilling process (Smol et al., 2015). The omission of toxic materials is taking place so that the product waste reaches the biocycle for the treatment. At last, the renewable energy plays a vital role in the generation of the product. This approach helps to convert the output of one cycle to the input of another cycle which is more consistent with the development of the CE.

10.5 Steps for achieving circular economy

In the past few decades, the CE has become a much discussed topic in different organizations. The steps needed for achieving a successful CE are depicted in Fig. 10.2. The CE is mainly dependent on the four loops, which is a prolongation of product life, reuse or redistribution of product, remanufacturing of product to enhance the performance, and recycling to make suitable for reuse purposes. To attain these goals, the companies need to put their effort in product design and the need to clearly represent the supply chain management (Goldsworthy, 2014). Additionally, they have to show their higher responsibility toward the user by giving the product as a service (Richter and Koppejan, 2016; Guo et al., 2017). Remanufactured fashion products are rising today. But it is an important notable point that the remanufactured fashion is the initial point of sustainability. Selling those remanufactured products to the consumers can be increased by selling at a low price, which stimulates high consumption.

The availability of remanufactured fashionable products in the store with the standard fabric would raise the utilization of those products. The marketing of remanufactured fashion should be aware of the remanufacturing aspects and their cost because the mass consumers should be satisfied with the cost they expected. At the same time, designers should not create nonstandard products at a high price; they have to create the products in such a way that standardizes simple designs. This way they can move forward to achieve the CE. The CE is aimed to dominate the linear model's take, make, disposal (Su et al., 2013). The success of the CE includes economic and stakeholders to activate the flow of materials which leads to higher advantages (Geng et al., 2012). Recent studies depicted that CE requires financial and legislative support (Fei et al., 2016; Levanen, 2015). Finally, the CE is involved with four main

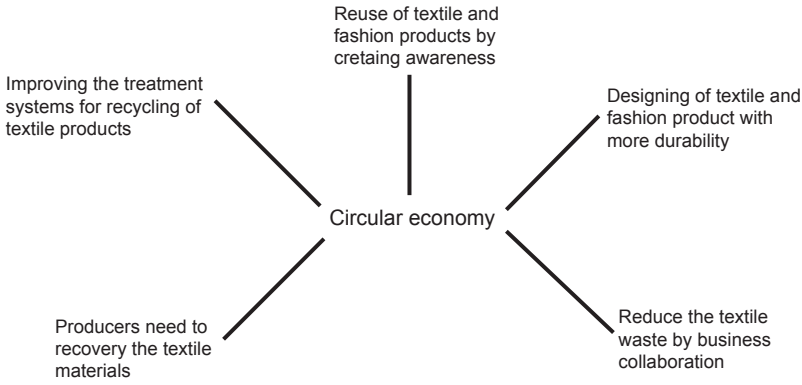

Figure 10.2 The flow diagram: circular economy steps.

aspects, which are its focus on reuse, recirculate, and recovery of material from waste, high-level method, main aim to achieve sustainable growth, and creation of innovations to get a successful CE.

10.6 Case study

In a pattern found with different products, cotton costs have turned out to be more unstable when the cost of the cotton increased from 2010 to 2011. From textile waste, about 40% of waste have been recycled and used in the production of MUD Jeans. The staying material is natural cotton, an asset that is liable to likewise, noteworthy value change and supply interruption, significantly more so than nonnatural cotton because of additional emphasis on the provenance of the material. Distinguishing the vulnerability of their production network, CEO Bert van Son chose to make more compelling utilization of the material that had just been purchased. van Son understood that the most solid method for recovering his item was to abstain from offering it in any case. Keeping in mind the end goal to hold control of the materials, van Son chose to start renting MUD Jeans, with various choices accessible. The pants are offered on a membership show, with the goal that repairs are free and clients can swap their pants for another combination. The outcome of this action is more adaptability for clients, more unsurprising material store network for MUD, and lower ecological effect related to jeans. He comprehends the strength that circularity could convey to his business, and how this will end up being a much more noteworthy upper hand later on.

10.7 Future trends

This chapter depicts the product waste and the barriers that related to the development of the CE model in the textile and fashion industry. The research may expand based on the inclusion of certain regulations in CE models. Researchers found that the accomplishing barrier leads to affect the CE scenario. By utilizing the available knowledge

there is a requirement to exhibit the CE toward the industries. To transform their waste into reliable resources they have to change their existing network to make suitable CE requirements. In case of the CE, clothes, fabric, and fibers enter into the reuse and never end in the form of waste. It relies on four objectives to achieve better economic, environmental, social results, and grabbing the events or opportunities neglected by the linear systems, which are it removes the substances based on concern and equalizes the ideas to produce safe materials and helps to convert the routes the clothes are assigned and provide a support to increase the disposable nature, lifespan, and utilization of textiles through brands. To maintain the quality of the fibers there is a need to recycle the textile waste after consumer usage, but it is found to be a very difficult and challenging issue in the textile and fashion industry. Because nowadays, the blend of fibers is available, which has a similar composition to normal fibers but are not the exact material of the fibers and hence is difficult to separate. So there is a need to the overcome this challenge by implementing the CE in the textile and fashion industry. In future industries may use various approaches to enhance a creative outcome and may create a difference in the CE.

10.8 Conclusion

The CE is more attractive toward industries and stimulates the sustainability and development of various industries though it has various barriers. But the CE is applicable only in few industries. The shifting to CE needs to analyze industrial capability, management disturbances, and their innovation complications. Generally, the barriers which were listed in this manuscript are most probably equal to the barriers to developing sustainability. This chapter invokes the usefulness of CE, which incorporates the textile and fashion industry in a successful development. By concentrating more on the CE, the textile industrial waste can be reduced and reused that brings out higher production volumes and lowers the cost. The relationship between remanufacturing, refurbishment, reusing, and recycling may enhance the innovations in a CE. Developing new techniques in preusage processes like extraction, manufacturing, assembling, and retailing makes the CE more standardized. The CE approach has the ability to minimize the global energy utilization. The energy saving method in the circular approach creates low demand for energy to both the consumers and government. In many industries, the energy usage depends on the materials employed for the production of the product. But this approach has the ability to reduce the energy, but their effect toward the material inputs will be higher. Along with the other advantages it can be considered as the main strategy for the reduction of energy demand.

References

Bakker, C.A., Wang, F., Huisman, J., den Hollander, M., 2014. Products that go round: exploring product life extension through design. Journal of Cleaner Production 69, 10−16.

Bocken, N., Short, S.W., Rana, P., Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production 65, 42−56.

Bostrom, M., Micheletti, M., 2016. Introducing the sustainability challenge of textiles and clothing. Journal of Consumer Policy 39 (4), 367−375.

Braungart, M., McDonough, W., Bollinger, A., 2007. Cradle-to-cradle design: creating healthy emissions − a strategy for eco-effective product and system design. Journal of Cleaner Production 15 (13-14), 1337−1348.

Fei, F., Qu, L., Wen, Z., Xue, Y., Zhang, H., 2016. How to integrate the informal recycling system into municipal solid waste management in developing countries: based on a China's case in Suzhou urban area. Resources, Conservation and Recycling 110, 74−86.

Fischer, A., Pascucci, S., 2017. Institutional incentives in circular economy transition: the case of material use in the Dutch textile industry. Journal of Cleaner Production 155, 17−32.

Franco, M.A., 2017. Circular economy at the micro level: a dynamic view of incumbents' struggles and challenges in the textile industry. Journal of Cleaner Production 168, 833−845.

Gallaud, D., Laperche, B., 2009. Building region-based sustainable development: vocabulary and tools. In: Circular Economy, Industrial Ecology and Short Supply Chain. John Wiley & Sons.

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017. The circular economy − a new sustainability paradigm? Journal of Cleaner Production 143, 757−768.

Geng, Y., Fu, J., Sarkis, J., Xue, B., 2012. Towards a national circular economy indicator system in China: an evaluation and critical analysis. Journal of Cleaner Production 23, 216−224.

Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production 114, 11−32.

Goldsworthy, K., 2014. Design for cyclability: pro-active approaches for maximising material recovery. Making Futures 3, 1−12.

Guo, B., Geng, Y., Sterr, T., Zhu, Q., Liu, Y., 2017. Investigating public awareness on circular economy in western China: a case of Urumqi Midong. Journal of Cleaner Production 142, 2177−2186.

Kama, K., 2015. Circling the economy: resource-making and marketization in EU electronic waste policy. Area 47 (1), 16−23.

Lacy, P., Rutqvist, J., 2015. Waste to Wealth The Circular Economy Advantage. Palgrave Macmillan.

Levänen, J., 2015. Ending waste by law: institutions and collective learning in the development of industrial recycling in Finland. Journal of Cleaner Production 87, 542−549.

Lewandowski, M., 2016. Designing the business models for circular economy-towards the conceptual framework. Sustainability 8, 1−28.

Lieder, M., Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. Journal of Cleaner Production 115, 36−51.

Lozano, R., Carpenter, A., Huisingh, D., 2014. A review of theories of the firm and their contributions to Corporate Sustainability. Journal of Cleaner Production 106, 430−442.

Malinauskaite, J., Jouhara, H., Czajczynska, D., Stanchev, P., Katsou, E., Rostkowsk, P., Thorne, R.J., Colon, J., Ponsa, S., Al-Mansour, F., Anguilano, L., Krzyzynska, R., Lopez, I.C., Vlasopoulos, Spencer, A., 2017. Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in Europe. Energy 141, 2013−2044.

Pitt, J., Heinemeyer, C., 2015. Introducing ideas of a circular economy. In: Stables, K., Keirl, S. (Eds.), Environment, Ethics and Cultures. Sense Publishers, Rotterdam, The Netherlands.

Pomponi, F., Moncaster, A., 2017. Circular economy for the built environment: a research framework. Journal of Cleaner Production 143, 710−718.

Preston, F., 2012. A Global Redesign? Shaping the Circular Economy. Chatham House, London.
Resta, B., Gaiardelli, P., Pinto, R., Dotti, S., 2016. Enhancing environmental management in the textile sector: an organisational-life cycle assessment approach. Journal of Cleaner Production 135, 620−632.
Richter, J.L., Koppejan, R., 2016. Extended producer responsibility for lamps in Nordic countries: best practices and challenges in closing material loops. Journal of Cleaner Production 123, 167−179.
Singh, J., Ordonez, I., 2016. Resource recovery from post-consumer waste: important lessons for the upcoming circular economy. Journal of Cleaner Production 134, 342−353.
Smol, M., Kulczycka, J., Henclik, A., Gorazda, K., Wzorek, Z., 2015. The possible use of sewage sludge ash (SSA) in the construction industry as a way towards a circular economy. Journal of Cleaner Production 95, 45−54.
Souza, G.C., 2013. Closed-loop supply chains: a critical review, and future research. Decision Sciences 44 (1), 7−38.
Stahel, W.R., 2013. The business angle of a circular economy e higher competitiveness, higher resource security and material efficiency. In: A New Dynamic Effective Business in a Circular Economy. Ellen Macarthur Foundation.
Su, B., Heshmati, A., Geng, Y., Yu, X., 2013. A review of the circular economy in China: moving from rhetoric to implementation. Journal of Cleaner Production 42, 215−227.
Todeschini, B.V., Cortimiglia, M.N., Callegaro-de-Menezes, D., Ghezzi, A., 2017. Innovative and sustainable business models in the fashion industry: entrepreneurial drivers, opportunities, and challenges. Business Horizons 60, 759−770.
Tukker, A., 2013. Product services for a resource-efficient and circular economy − a review. Journal of Cleaner Production 97 (15), 76−91.
Webster, K., 2015. The Circular Economy: A Wealth of Flows. Ellen MacArthur Foundation Publishing, Cowes, UK.
Whicher, A., Harris, C., Beverley, K., Swiatek, P., 2018. Design for circular economy: developing an action plan for Scotland. Journal of Cleaner Production 172, 3237−3248.
Williams, I.D., 2015. Forty years of the waste hierarchy. Waste Manag. (New York, N.Y.) 40, 1−2.

Further reading

Braungart, M., McDonough, W., 2002. Cradle to Cradle; Remaking the Way We Make Things (New York).

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THE TEXTILE INSTITUTE BOOK SERIES

Circular Economy in Textiles and Apparel

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About the Editor

Dr Subramanian Senthilkannan Muthu holds a PhD in Textiles Sustainability and has written / edited around 65 books and 80 research publications. He is currently heading the department of Sustainability for SgT and API based in Hong Kong. He has a decade's experience working in sustainable textiles and clothing, and has worked with hundreds of factories in Asia and Europe on their sustainability issues. He is acting as an editor, editorial board member and reviewer for many international peer-reviewed journals of textiles and environmental science disciplines. He is one of the directors of Textile and Bioengineering Informatics Society (TBIS), which is a charitable organization created to foster, develop and promote all aspects of science and technology in bioengineering of materials, fibers and textiles.

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ISBN 978-0-08-102630-4
9 780081 026304