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Department of Business and Management

Chair of Organizational Design

Circular business models in the denim industry:

The case of MUD Jeans

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Introduction

Today's competitive scenario requires a marked ability to adapt to changing needs and trends.

The most peculiar element of the contemporary context is the growing centrality of sustainability issues, an inevitable consequence of the environmental disasters we witness every day due to climate change. The scale of the problem is so great that it affects everyone, without exclusion; hence, everyone, - from individuals, to governments, to companies - is involved in seeking solutions that can stem the problem. As far as the role of companies is concerned, they have the responsibility to rethink each stage of the product life cycle in order to renew their business models, i.e., the tool that describes how a business creates value for its customers and by what means it manages to do so.

The decision to contextualise this reflection in the fashion sector is justified, first of all, by the central role this industry plays in terms of environmental impact and social responsibility. For a more detailed and in-depth analysis, the focus has been placed on the denim industry, one of the most polluting sectors within the textile industry due to the numerous toxic substances used in its production process.

The first chapter opens with a brief presentation of the origin and characteristics of the Linear Economy Model, which appears to be no longer adequate for the socio-economic and environmental challenges that society is facing today. The evidence provided on the limitations of this model will shift the discussion to the concept of the Circular Economy, proposed as a sustainable alternative to the Linear Model. However, in order for this theoretical model to find concrete application within the current economic system, it is necessary for companies to implement radical changes within their business models. Therefore, the main theories concerning the different existing Circular Business Models will be presented, with a particular focus on the fashion industry.

In the second chapter, after defining the characteristics of the fashion industry, the environmental impact of the textile industry will be analysed. Despite the considerable progress made in recent years - thanks to the development of new technologies - the textile industry still faces many challenges for an effective large-scale transition to a closed-loop system.

After a brief introduction on the state of the denim market and an in-depth look at the various types of denim, it will be described how denim is generally produced. To conclude, the key sustainability issues of the denim industry will be analysed, based on the three sustainability pillars of social, environmental, and economic sustainability.

Finally, the third chapter will be dedicated to the analysis of the business case of MUD Jeans, a company pioneering the production of circular denim. The introduction of the company and of its supply chain, will be followed by the description of its innovative "Lease A Jeans" concept, and an in-depth analysis of the MUD Method, a simple but effective circular business model, showing that producing without wasting resources is indeed possible.

Chapter I – From the linear model to the circular business model

1.1 The Linear Model

Between the end of the 19th century and the beginning of the 20th century, mankind experienced a period of rapid economic and scientific development; the unprecedented technological progress that followed the Industrial Revolution and especially the post-World War II period led to a rapid increase in wealth and, as a result, gave rise to and nurtured the idea of infinite availability of resources, materials, and products.

This illusion of infinite resources has been both cause and effect of the development of the linear economy, which is based on the "take-make-dispose" model. According to this production and consumption model, the life of each product is essentially marked by five stages: extraction, production, distribution, consumption, and disposal (see Figure 1). This means that industry extracts virgin raw materials, processes them to produce consumer goods using labour and energy, distributes the products to the consumer, who, after using them, disposes of the products, which have now become "waste".

***Figure 1**: The linear economy. Source: personal elaboration.*

According to this economic model, every consumer good goes from "cradle to grave", meaning that products have a beginning and an end, and that their life ends in landfills, where the material becomes waste, unusable for productive purposes. This way of producing and consuming would only work if resources on Earth were infinite; on the contrary, the resources the planet can offer are limited, finite, and exhaustible, especially at the rate at which they are being extracted and used today.

It is clear that a development model that envisages unlimited growth in consumption is opposed to the concept of sustainability, which is why the linear economic system went into crisis in the second half of the 20th century, precisely with the emergence of energy crises and pollution phenomena on a global scale.

It is now recognised worldwide that such a use of resources, combined with constant population growth, increasing consumption and often inefficient use of resources, is no longer sustainable. The emergence of environmental problems and the limits of available resources (i.e., energy and raw materials) has therefore prompted the scientific community to re-evaluate the relationship between the economy and the environment, in favour of more sustainable models.

1.1.1 Limits of the Linear Model

As mentioned in the previous section, the linear model is based on certain assumptions, namely the abundance of readily available resources and an infinite regenerative capacity of the Planet. However, these assumptions are no longer valid in the current global context and numerous factors indicate that the power of the linear model is reaching its limits.

By 2030, the population on Earth is expected to reach 8.5 billion, and this number is projected to rise to around 9.7 billion in 2050 (United Nations Department of Economic and Social Affairs, 2021). To respond to the increasing global demand, approximately three times the resources currently used will be needed, unless a way is found to decouple economic growth from environmental degradation (UNEP, 2011). It can be expected that GDP per capita in developing countries will also increase, with a consequent increase in CO2 emissions and waste production, whose contribution from developed countries is currently more than three times higher than developing countries; in our current economy, global consumption needs 1.5 planet Earths to sustain itself and this will increase with the rising middle class (ING Economics Department, 2015). In addition, negative environmental externalities associated with the current living standards in developed countries, such as climate change and the loss of biodiversity, are becoming clearly felt (FinanCE, 2016).

Despite the fact that in recent decades the growing awareness of consumers, companies, and institutions towards sustainability issues have resulted in significant improvements,

environmental and social pressures are likely to increase further due to population growth, globalisation of markets and increasing resource consumption.

To further complicating this dramatic scenario there is the scarcity of non-renewable resources on which the current linear economic model is based. Indeed, there is growing consensus that ecosystems, fossil fuels, and minerals are slowly but surely being depleted, as illustrated by Figure 2 (BBC, 2012).

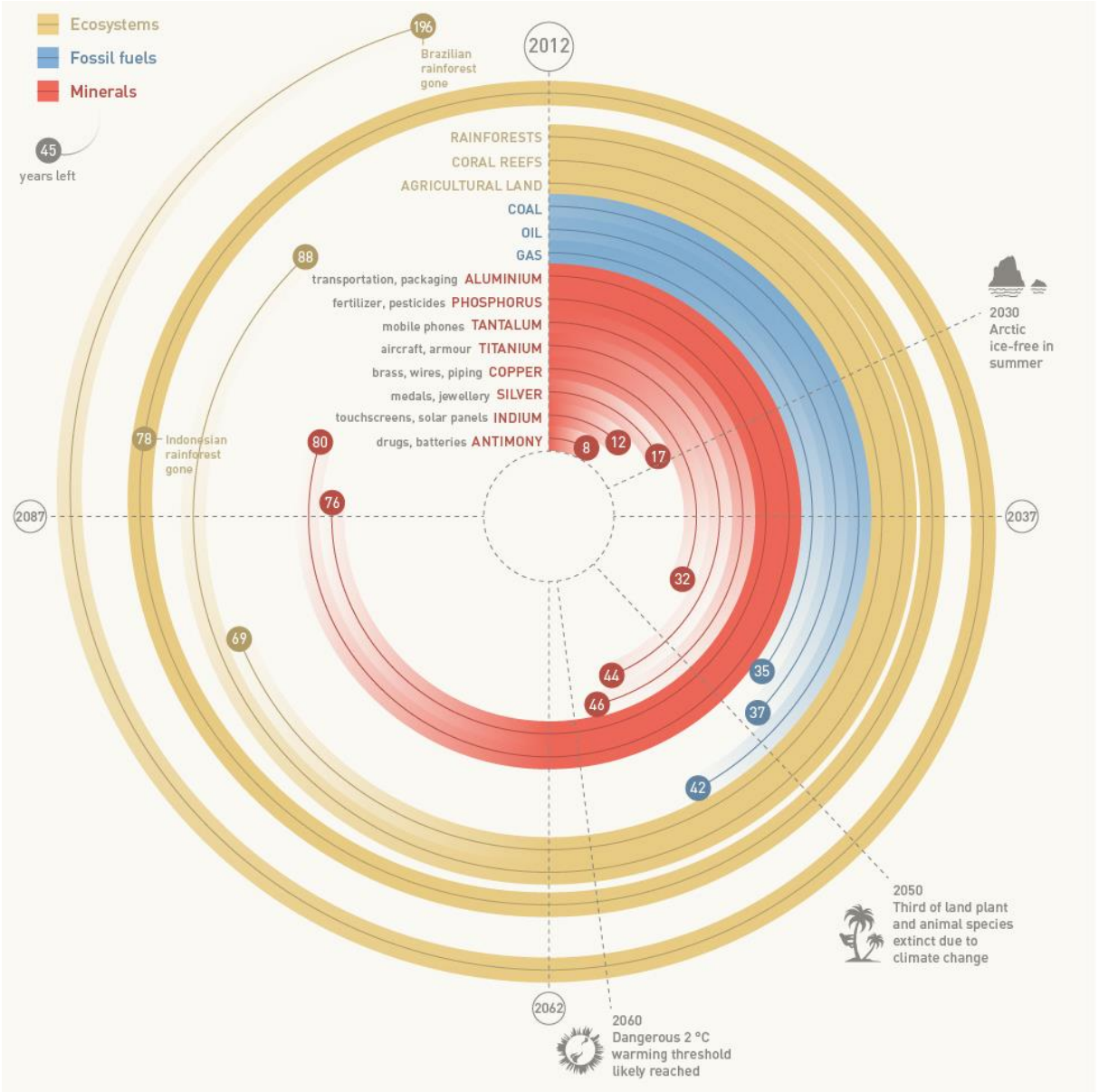

***Figure 2**: Estimated remaining world supplies of non-renewable resources. Source: BBC (2012).*

Moreover, a growing number of companies feel trapped between rising and less predictable prices in resourcing markets on one side and high competition and stagnating demand in some sectors on the other (Ellen MacArthur Foundation, 2013a).

Faced with the socio-economic and environmental challenges presented above, governments and businesses are increasingly recognising that the current linear economic model is no longer sustainable. The fundamental need to find an alternative to the traditional growth model has originated the debate on the circular economy.

1.2 The origins of the Circular Economy

It is difficult to trace the concept of Circular Economy back to one single date or author, however, practical applications to modern economic systems and industrial processes date back to the 1970s (Ellen MacArthur Foundation, 2013b).

The idea of a circular system was first presented in 1966 by economist Kenneth E. Boulding in his article "The Economics of the Coming Spaceship Earth". In the article, Boulding outlines two types of economies, one closed and one open, identifying them with two figures, the cowboy and the spaceman:

> *"The closed earth of the future requires economic principles which are somewhat different from those of the open earth of the past. For the sake of picturesqueness, I am tempted to call the open economy the "cowboy economy," the cowboy being symbolic of the illimitable plains and also associated with reckless, exploitative, romantic, and violent behavior, which is characteristic of open societies. The closed economy of the future might similarly be called the "spaceman" economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy"* (Boulding, 1966).

The cowboy merely considers the endless plains that surround him, driven by a continuous thirst for conquest and consumption, while the spaceman has a profound awareness of his host system, the spaceship Earth, its limits and the cycles that regulate its functioning. Similarly, Boulding outlines two contrasting economies, the open economy of the past and the closed economy of the future. The first, that of the cowboy, is the one that has characterised the world economic system in the last century, where production and consumption are considered a

measure of the well-being of the population and the success of the economy, and the reservoirs from which to extract raw materials, and those into which to dump production waste, are considered unlimited. In contrast, the economy of the future is closed, and as the spaceman, mankind should be aware that the resources available on Earth are limited, and therefore try to minimise waste. In this scenario, the economy and the environment should coexist in equilibrium, and this is only possible by preserving the resources already in circulation.

A further contribution to the development of the idea of a circular system was given in 1971 by the biologist Barry Commoner, who, in his well-known book "The closing circle. Nature, man and technology", wrote:

"(…) the earth's life system had an inherently fatal fault: the energy it required was derived from the consumption of a non-renewable resource, the geochemical store of organic matter. Survival became possible because of a timely evolutionary development: the emergence of the first photosynthetic organisms. These new organisms used sunlight to convert carbon dioxide and inorganic materials to fresh organic matter. This crucial event reconverted the first life-form's waste, carbon dioxide, into, its food, organic compounds. It closed the loop and transformed what was a fatally linear process into a circular, self-perpetuating one" (Commoner, 1971).

The concept of "closing the circle" soon became clear from a scientific and ecological point of view, but its correlation with the economic sphere was not immediately understood.

In 1976, the architect Walter Stahel, together with Geneviéve Reday-Mulvey, published a technical report for the European Commission entitled "The Potential for Substituting Manpower for Energy", in which they analysed the issue of the waste of resources linked to the rapid disposal of consumer goods (Stahel & Reday, 1976). In that report, a description of a new economic model that differed from the linear economy appeared for the first time: the loop economy. The report showed that three-quarters of industry's energy consumption was associated with the extraction and production of raw materials, while only one third was used in actual production processes. According to the authors, therefore, by reusing products instead of manufacturing new ones, labour would replace energy consumption, leading to energy savings and the creation of new jobs. Stahel also emphasised the sale of utilisation, rather than ownership of goods, as one of the most effective business models for a loop economy, an idea summarised today in the notion of "performance economy" (Ellen MacArthur Foundation, 2013b). In this way, industries could generate profits without externalising the costs and risks derived from waste (Geissdoerfer et al., 2017).

In those same years, the concept of “Regenerative Design” was born by John Tillman Lyle (Lyle, 1996), an American professor of landscape architecture. Lyle challenged his students to envision “*a community in which daily activities were based on the value of living within the limits of available renewable resources without environmental degradation*”, according to the Lyle Center for Regenerative Studies (CalPolyPomona, 2022). In the following years, students, and faculty at Cal Poly Pomona University, studied the possibilities of creating a community that made use of on-site resources, working with renewable and bio-based processes. Since then, the term “Regenerative Design” has been used in reference to all those systems that, like agricultural systems, could be managed in a regenerative manner, i.e., where the processes themselves renew and regenerate the energy sources and materials consumed (Ellen MacArthur Foundation, 2013b).

Janine Benyus, a biologist and author of the book “Biomimicry - Innovation inspired by nature” (Benyus, 1997), also recognised the key role of engineers, architects and designers in re-imagining a more environmentally sustainable world. In doing so, according to her, Nature can be a fundamental source of inspiration. In fact, all of man's inventions are already present in nature, but in a more elegant and less wasteful form for the planet: for example, the beams and struts used in architecture are present in the stems of water lilies and bamboo; our best radars are nothing compared to the ability of bats to transmit multi-frequency signals. Biomimicry, therefore, studies the patterns nature provides, imitating them or taking inspiration from them to find solutions to human design challenges, using ecological standards to judge the goodness of innovations.

The environmentalist Paul Hawken, along with other authors, described how economic and environmental interests can be pursued through the same principles. These basic principles are as follows: increasing the productivity of natural resources; using biologically inspired models and materials; moving to a business model that provides services instead of products; and, finally, reinvesting in natural capital so as to continually restore the resources found in nature (Lovins et al., 1999).

Careful management of material flows plays a central role in building a circular economy (Ellen MacArthur Foundation, 2013b). McDonough and Braungart, authors of the book “Cradle to Cradle: Remaking the Way We Make Things”, consider all materials involved in industrial and commercial processes as nutrients, which are of two types:

- Biological nutrients: non-toxic materials that can be naturally broken down and reintroduced into the biosphere after use. They are returned to the environment through composting or anaerobic digestion, sometimes producing substances of higher value.
- Technical nutrients: synthetic materials, designed to be reused in a closed circuit without losing their quality. In this way, these materials can be used over and over again, avoiding "downcycling" into smaller products, ultimately becoming waste (Braungart et al., 2007).

According to the two authors, it is essential to eliminate the concept of "waste", avoiding mixing these nutrients to create hybrids that cannot be recycled, but instead designing products entirely made of biological or technical nutrients, whose components can be recovered, thus giving rise to so-called "upcycling".

The *Cradle to Cradle* philosophy, in opposition to the linear *Cradle to Grave* model that dominates the modern industry, focuses on improving the positive impact of products (Toxopeus et al., 2015). In fact, in contrast to the traditional eco-efficiency approach, whose objective is to reduce the negative impact of production and consumption processes, the *Cradle to Cradle* design approach aims at eco-effectiveness, by developing products that maintain or even enhance the quality and productivity of materials through subsequent life cycles (Braungart et al., 2007).

Besides the elimination of the concept of waste, the main principles of the *Cradle to Cradle* design paradigm include also the use of renewable energy and the support of diversity in all its forms as a driver of creativity and innovation (Toxopeus et al., 2015).

Throughout the twenty-first century, ideologies in favour of decoupling economic growth from resource and energy consumption have spread, giving rise to sustainable development models. As early as 1998, the German scientist Ernst Ulrich von Weizsäcker published "Factor Four: Doubling Wealth - Halving Resource Use" in which he argued that growth and sustainability can coexist and that human civilisation can thrive without the depletion of natural resources (Weizsäcker et al., 1998). For this to be possible, according to the scientist, it is necessary to quadruple the value extracted from available resources. A few years later, in 2009, the same author published "Factor Five: Transforming the Global Economy through 80% Improvements in Resource Productivity" in which he outlined some companies, operating in different sectors, that managed to quadruple their resource efficiency (von Weizsacker et al., 2009).

1.3 The principles of Circular Economy

The Circular Economy is an economic model that brings together and integrates, within a single system, the different schools of thought described above.

The most widely accepted definition of the Circular Economy is the one provided by the Ellen MacArthur Foundation, a non-profit organisation working since 2010 to spread the Circular Economy at international level, which defines it as "*an industrial economy that is restorative by intention. It aims to enable effective flows of materials, energy, labour and information so that natural and social capital can be rebuilt*" (Ellen MacArthur Foundation, 2013b).

Circular Economy therefore envisages an upstream reorganisation of production activities so that waste materials can be recovered or recycled in order to avoid leakages at different stages of the production cycle. These are all those points in the cycle where there is a loss of efficiency, as potentially still useful and valuable material escapes the production system or is consumed. The Circular Economy aims to prevent such leakages, by reducing the incoming flow and quantities of raw materials and natural resources.

Analysing the literature on Circular Economy, three main "actions" emerge, namely the 3R's Principles: Reduction, Reuse and Recycle (Ghisellini et al., 2016):

- Reduction: to produce and consume using the least possible amount of inputs, such as energy and raw materials, and limiting the emission of environmentally harmful outputs, by improving the efficiency of production and consumption processes.
- Reuse: "*any operation by which products or components that are not waste are used again for the same purpose for which they were conceived*" (EU, 2008).
- Recycle: "*any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations*" (EU, 2008).

Although Circular Economy is often associated with recycling, in fact, this is the least sustainable of the three solutions, both in terms of efficiency and profitability (Ghisellini et al.,

2016), as it is limited by the very components a product is made of, depending on whether these are recyclable or not. For example, cellulose fibres can be recycled a maximum of six times.

Of all of them, re-use is the action with the greatest environmental benefits: it requires fewer resources, less energy and less labour and its diffusion generates a virtuous cycle, such that an increase in demand for re-usable products corresponds to an incentive for the supply to design durable goods for multiple cycles (Ghisellini et al., 2016).

The 3R principles can be integrated by three additional principles (Ellen MacArthur Foundation et al., 2015), as also shown in Figure 3:

- **Principle 1**: *Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows*. To this end, the utility should be delivered virtually – for example books or music, online shopping, and virtual offices – when possible. When physical consumption of resources is necessary, Circular Economy carefully selects the resources to be used and chooses, whenever possible, technologies and processes that use renewable or high-performing resources. As for the enhancement of natural capital, nutrient flows within the system should be encouraged and the best conditions for regeneration of, for example, soils should be created.
- **Principle 2**: *Optimise resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycle.* As already described, biological materials are safely reintroduced into the biosphere in order to be transformed into new resources; technological materials, on the other hand, are originally designed to be recovered and upgraded. In both cases, tighter, inner loops are always preferred, as they conserve more value and energy.
- **Principle 3**: *Foster system effectiveness by revealing and designing out negative externalities* which, according to Classical economic theory, are tolerable and sometimes necessary sides effects of production and exchange, while they are condemned by the Circular Economy, which instead promotes an economic model that reduces damage to people and the environment.

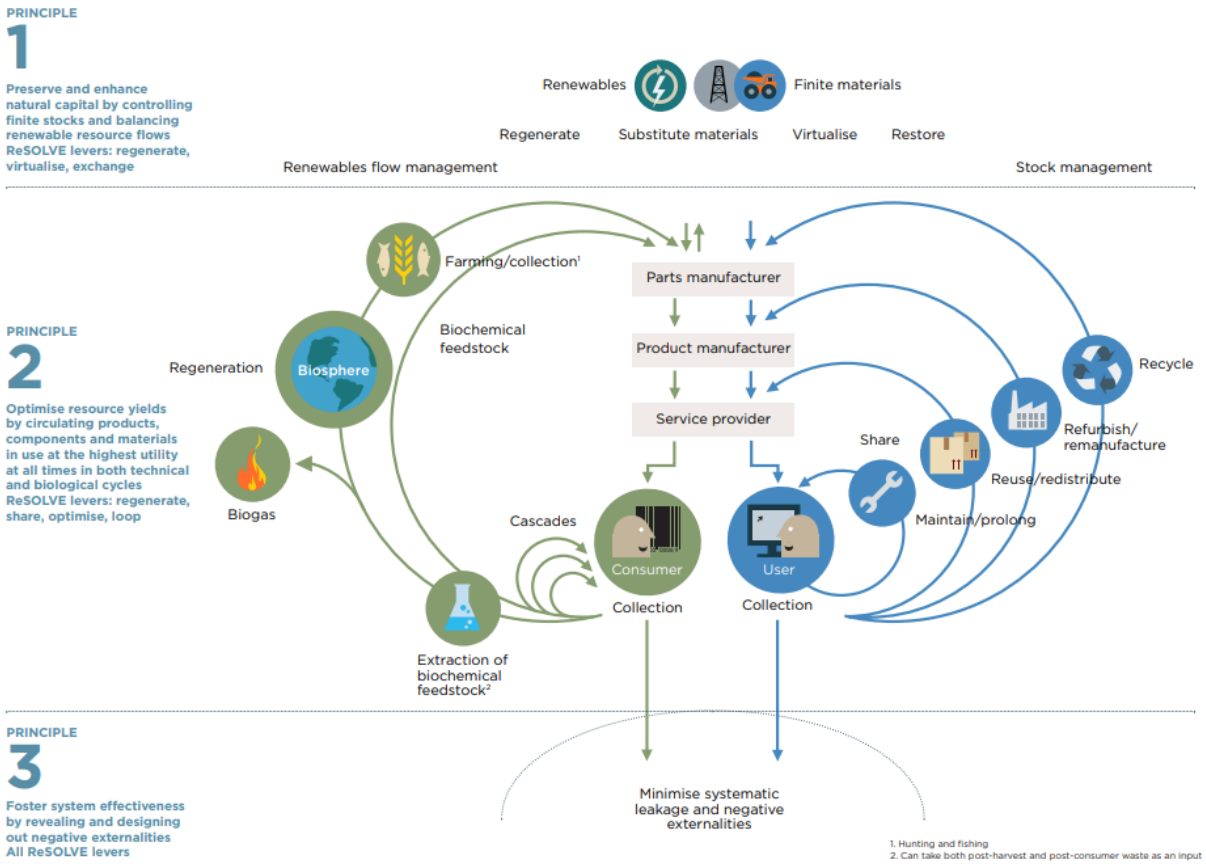

***Figure 3**: Circular economy principles. Source: Ellen MacArthur Foundation et al., (2015).*

The principles described above represent a guide to the implementation of actions oriented towards circularity. From these it is possible to derive some milestones that summarise the various theories from which the Circular Economy originates (Ellen MacArthur Foundation et al., 2015):

Design out waste. In Circular Economy, waste does not exist; what is waste material in one cycle becomes raw material in another, according to cascading mechanisms. The difference from normal recycling in linear systems is that here the asset is designed at source to be recovered, allowing the minimisation of energy used and the maximisation of value retention.

Build resilience through diversity. In an uncertain and ever-changing world, diversity is the key to versatility and resilience within a system. Just as in living systems biodiversity is essential to cope with external perturbations, similarly in economic systems it is necessary to balance the various business dimensions, to ensure prosperity in the long run.

Shift to renewable energy sources. The use of renewable energy sources to support the Circular Economy model aims to reduce dependence on fossil fuels, thereby increasing the resilience of the system, in case of, for example, shocks in the oil market.

Think in systems. Businesses, people and the environment are part of a complex system in which each element is closely related to the other. A systems approach studies these connections to design effective as well as efficient non-linear systems.

Think in cascades. Cascading is the strategy of using, sequentially and continuously, raw materials and products made from them as long and efficiently as possible, and only to recover energy from them at the end of their life cycle, making full use of the "added value" of materials. (Campbell-Johnston et al., 2020).

1.4 Business Model innovation

For Circular Economy to find concrete application within the current economic system, it is necessary for companies to implement radical changes in the management of production processes, as well as in the actual production phase.

In general, Business Models define the organisational and strategic solutions that enable a company to create and distribute value while gaining a competitive advantage (Baden-Fuller & Morgan, 2010). For an established organisation, the shift towards a circular economy is a radical one, involving a total rethinking of the company's business. In fact, for most of the twentieth century, business models were based on integrated production, internal research and development, direct sales, and unit pricing (Frankenberger et al., 2013). However, in recent years, the success of new innovative business models, such as Apple's invasion of the music industry or Ikea's conquest of the furniture market, has shown that product innovation alone is no longer sufficient to remain competitive, but must be implemented in every dimension of the company.

The term "Business Model Innovation" is used in an increasing number of scientific publications, even though it does not yet have a commonly accepted and generally valid definition (Schneider & Spieth, 2013). In general terms, "Business Model Innovation" refers to a new way of creating and capturing value, achieved by changing one or more components in the

business model (Frankenberger et al., 2013). At the same time, an innovative business model can only be defined as such only if it is perceived as new by customers.

In 1939, Peter Schumpeter defined innovation as "*the introduction of new commodities which may even serve as the standard case. Technological change in the production of commodities already in use, the opening up of new markets or of new sources of supply, Taylorization of work, improved handling of material, the setting up of new business organizations—in short, any 'doing things differently' in the realm of economic life"* (Schumpeter, 1939).
This definition could still be considered relevant, if it did not overlook the impact that such changes have on the external environment, a topic that has become central to the discussion in the last decade. It is therefore important that an innovation, to be considered as such, is associated with a significant positive change from the status quo (Berkun, 2010).

In this respect, the development of new Business Models within the Circular Economy, as an economic model based on sustainable growth, can be considered a case of innovative strategy. A Circular Business Model exploits the reuse and recycling of resources, both with a view to saving resources, and thus costs, and reducing environmental impact.

1.5 Circular Business Models

While the concept of the Circular Economy dates back to the 1980s, scientific production on how it can be translated into new business models is limited.

According to a study published by the Ellen MacArthur Foundation, Circular Business Models can be grouped into three categories (Ellen MacArthur Foundation, 2021a):

- *More use per user*. This category includes all those models that are based on a more extended use of the good by the consumer. This strategy is opposed to the so-called "planned obsolescence", i.e., the reduction of the life cycle of products to a fixed duration in order to increase demand for them and relies instead on the design of more durable products and the education of consumers in their use.
- *More users per product*. These models involve the use of platforms and/or services that facilitate the exchange and/or sharing of products between consumers in order to limit purchases and extend the life of goods.

- *Beyond physical products*. As already mentioned, new digital technologies create several opportunities for the introduction of new business models, such as "servitisation", which shifts the focus of the company not on selling the product but on providing the service, thus leaving the physical ownership of the product with the company. It must be emphasised, however, that digitisation brings with it a great environmental impact; the digitisation process must therefore be carried out with awareness, so that the circular benefits outweigh the intrinsic impact of digital technologies.

As a result of the analysis of more than 120 case studies of companies that are generating resource productivity improvements in innovative ways, Accenture has identified within these categories five underlying business models driving the Circular Economy, whose mechanism is shown in the figure below (Accenture, 2014).

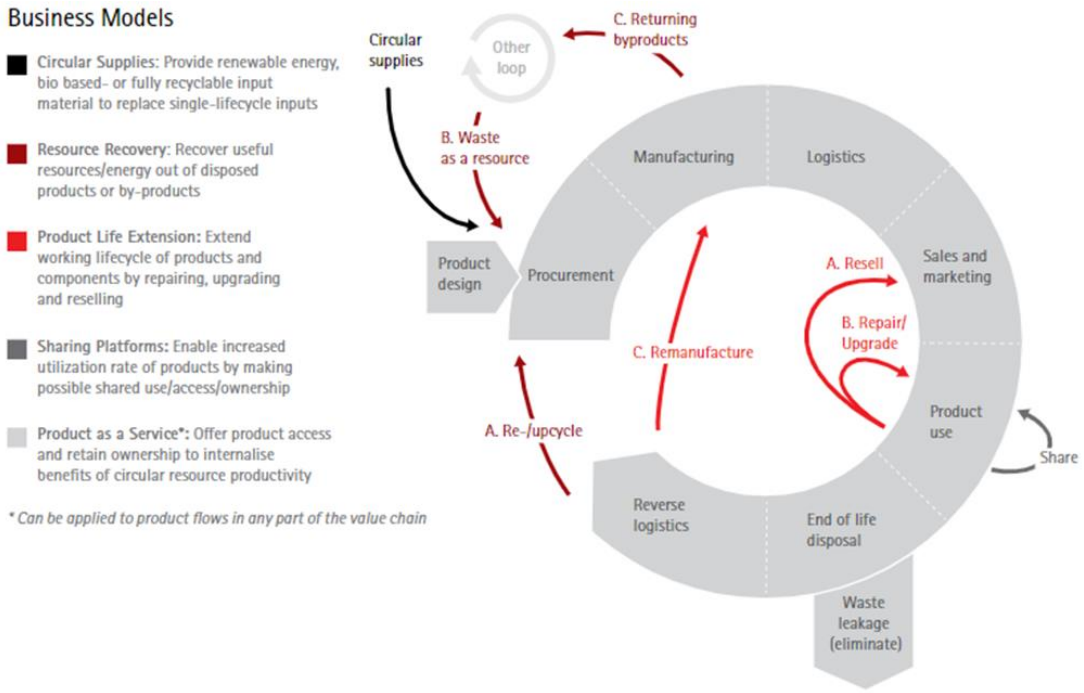

***Figure 4**: The five circular business models. Source: Accenture (2014).*

Circular Supplies

These models replace the scarce resources traditionally used in linear models with fully renewable, recyclable, or biodegradable resources. The former consists of resources that are

present in nature and can therefore be reused repeatedly, such as solar and wind energy; recyclable materials can be associated with what McDonough and Braungart called “technical nutrients”, i.e., man-made materials that can be recycled indefinitely without loss of quality; finally, biodegradable resources are the so-called “biological nutrients”, which can be returned to the environment with zero impact.

By freeing themselves from increasingly unavailable and sometimes toxic commodities, raw material suppliers achieve two main advantages. First, they secure safe, more predictable, and cost-effective raw materials and energy sources in the long run. Secondly, adopting such a model provides a competitive advantage over demand. In fact, when faced with a comparable offer in terms of price and quality, most companies would choose a sustainable alternative to a “traditional” one, also in view of the growing awareness of sustainability issues (Lacy et al., 2020).

Resource Recovery

This model is the most widespread within the Circular Economy and consists of limiting the waste of resources by recycling those already present within the system. The objective of this model is to transform what would normally be considered waste destined for landfill, into a resource that can guarantee an economic return. The maximum attainable result would be the creation of plants at a level of efficiency that eliminates waste. However, the latter still represents an ideal scenario and, therefore, other actions must be pursued, such as the reintroduction upstream or at other stages of production, of goods at the end of their life cycle, in order to be able to generate new ones from the materials they contain or restore them as new.

Companies willing to pursue and implement such a model face two main challenges: finding ways to control the flow of materials, creating a cost-sustainable take-back system, and investing in remanufacturing and finishing processes in order to enable the full recovery of the technical characteristics of the collected materials (Lacy et al., 2020). Otherwise, it would not be possible to create a source of competitive advantage through this model.

Product Life Extension

This model can be considered an evolution of the previous model. Product life extension can be achieved in several ways. A first solution could be to sell the longevity of the product itself to the market, by targeting customers who are looking for products that last and are willing to pay more for them. It is also possible to sell goods that have been repaired and restored to

their original state on second-hand markets, targeting particularly price-sensitive consumers, or to generate revenue by selling upgrades of the product sold. Finally, it is possible to offer maintenance and repair services, addressing those customers who are satisfied with the product and do not want to replace it with another.

Sharing Platforms

This business model is based on maximising the exploitation of goods by lending them temporarily to non-owners. In other words, by means of special digital platforms, owners of certain products can 'share' them with other parties interested in using them during periods when they would otherwise remain unused. This model benefits four categories of stakeholders:

- The owner of the good, who can extract a profit from it, by lending it or simply sharing it with others.
- The temporary user, who can satisfy a particular need without having to buy the good associated with it.
- The owner of the sharing platform, who does not have direct possession of the good but who, by connecting the owner of the good and the customer, is able to generate revenue through percentage fees charged on transactions that take place on his platform, and the sale of data collected on users.
- Finally – and most importantly – the environment. In fact, thanks to sharing, consumption can increase without increasing production, reducing environmental impacts.

Sharing platforms can be divided into different categories depending on the type of users they aim to connect. Consumer to Consumer (C2C) platforms allow consumers to interact with each other. Business to Business (B2B) platforms allow companies to gain visibility in order to lend out assets with low utilisation rates so as to amortise their purchase and maintenance costs. Conversely, companies that do not own such assets have the opportunity to exploit them while not becoming their owners. Finally, Business to Consumer (B2C) platforms, are particularly used by companies adopting the Product as a Service business model (see next paragraph).

Product as a Service

Similarly to the previous business model presented, the Product as a Service model is based on the concept of using, for a defined period of time, an asset owned by others. The difference, in this case, is that the sharing does not take place between actors operating at the

same level of the supply chain, as in C2C and B2B cases, but is a vertical type of sharing in which the company retains ownership of the product and grants the right to use it to the customer by selling to the latter the benefits deriving from its use (Lacy et al., 2020). Hence, it is a B2C model, which offers considerable cost savings to those consumers who only need the product in question for a certain period of time, and therefore do not intend to buy it.

This business model can be implemented in different forms. Companies can offer their assets for rent or lease (e.g., car sharing services), or by adopting the "pay for use" model, where customers pay for the temporary use of the asset on the basis of a specific indicator (e.g., Michelin, a leading tyre manufacturer, which allows its customers to rent tyres, paying a fee based on kilometres driven).

The results of the Accenture study are in line with those presented by Geissdoerfer et al. (2020) who, based on an in-depth literature review, outline four general strategies for circular business models, summarised in Figure 5.

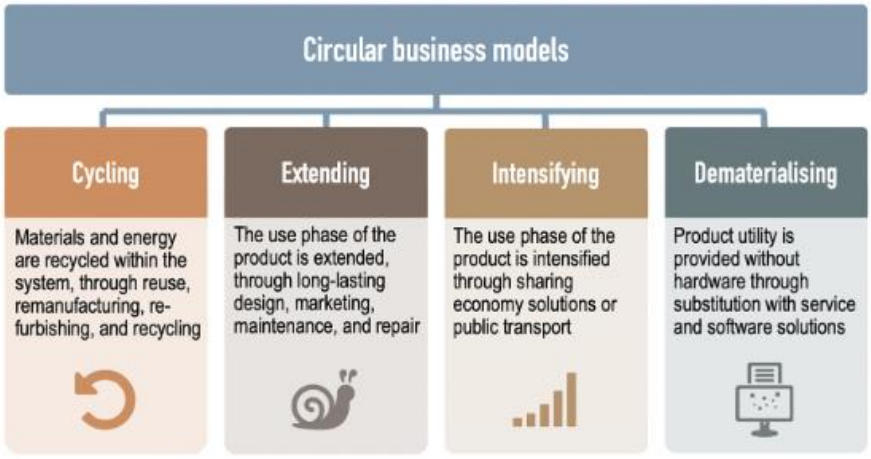

***Figure 5**: Circular business models strategies. Source: Geissdoerfer et al., (2020).*

- **Cycling**: this strategy refers to all those systems involving the reuse, remanufacturing, refurbishing, and recycling of materials and energy. Recycling is the most common strategy within circular business models, as it is associated with cost-minimisation benefits and higher profits.
- **Extending**: this strategy aims to extend product life as long as possible, mostly through durable and timeless design, marketing campaigns that encourage long-term use, and repair and maintenance services.

- **Intensifying**: following the “more users per product” concept, this strategy refers to those solutions that enable the intensified use of products, such as sharing economy or public transport.
- **Dematerialising**: the substitution of physical products with services or software solutions is a useful strategy to reduce over-production, while at the same time improving the customer experience (Geissdoerfer et al., 2020).

For the sake of convenience, in reality, organisations that decide to adopt a circular business model often focus on only one of these strategies. However, it is important to emphasise that hybrid models that combine some or all these strategies within a single business model are also possible (Geissdoerfer et al., 2020).

For the purposes of this work, it is of particular interest to understand whether there are and what are the main Circular Business Models for companies operating in the fashion sector, and whether these have particular characteristics that differentiate them from the models reported so far.

1.5.1 A focus on the fashion industry

The Ellen MacArthur Foundation recently published “Circular Business Models: Redefining growth for a thriving fashion industry”, a study that explores the role of Circular Business Models in the fashion industry. The study identified four main Business Models – Resale, Rental, Repair, Remaking– representing a USD 73 billion market in 2019 (Ellen MacArthur Foundation, 2021a).

Resale

The Resale model consists of the sale of second-hand garments. The company adopting it aims to implement the "take-back scheme" of garments under its own brand, whereby products are returned by customers and resold as second-hand garments in shops by the company itself or through a third party (Watson et al., 2014).

According to the annual Resale Report published by ThredUp, the number of brands with resale shops grew by 275% in 2022 compared to 2020 (ThredUp, 2022). This is an indication of how brands recognise the potential of this market, which is predicted to grow three times faster than the total global apparel market (see Figure 6).

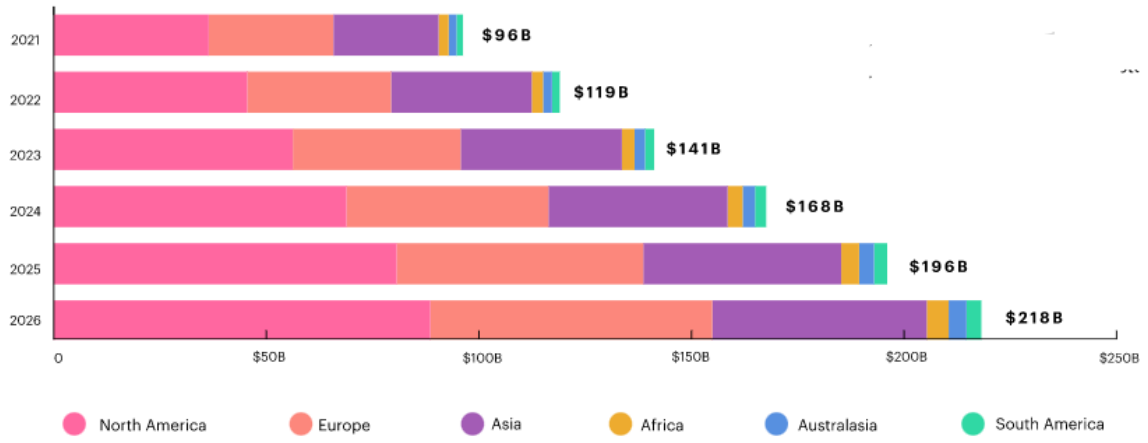

***Figure 6**: Expected growth of the second-hand market. Source: ThredUp (2022).*

The second-hand clothing market attracts consumers of all ages, but in particular younger ones: 62% of Gen Z and Millennials involved in the survey declared that before buying a new garment they look for it on the second-hand market and almost half of them spend a greater share of their budget on second-hand than five years ago (ThredUp, 2022).

The adoption of the Resale model therefore represents a great opportunity for brands, which in this way are able to reach a customer segment that is expected to grow more and more in the coming years, while at the same time obtaining an important return in terms of brand image enhancement, thanks to the innovative and sustainable concept, and its protection, thanks to direct control over resale.

On the other hand, the model requires the construction of an effective narrative to attract consumers and a rethink in organisational and logistical terms, given the product responsibility extended beyond the moment of sale, such as washing and quality control of garments. It is also of great importance to differentiate the offer to avoid the risk of cannibalisation of new product sales by second-hand goods.

Rental

The Renting Model consists of offering the consumer the possibility of renting a product, of which the company retains possession and is responsible for maintenance upon its return. This model is proposed as an alternative to personal ownership, replacing it with the use of the product, increasing its longevity, cutting unnecessary consumption, and reducing the use of natural resources. In addition, it makes luxury products more accessible, creates a community

among subscribers, gives consumers access to a continuously renewable wardrobe, and decreases customer uncertainties, especially for more expensive products (Hu et al., 2014).

Introducing this model into a traditional business does not require immediate adjustments in product design and production, so the cost and time of implementation can be relatively limited. Furthermore, it has the advantage of being able to collect much more data on consumer behaviour and preferences than a normal retail system (Hu et al., 2014). However, product liability is extended to additional care such as washing and repairing garments, so the supply chain becomes more complex than in traditional retail (see Figure 7). Rental also requires a form of administration supported by dedicated software and a strong online presence to reach as wide a market as possible.

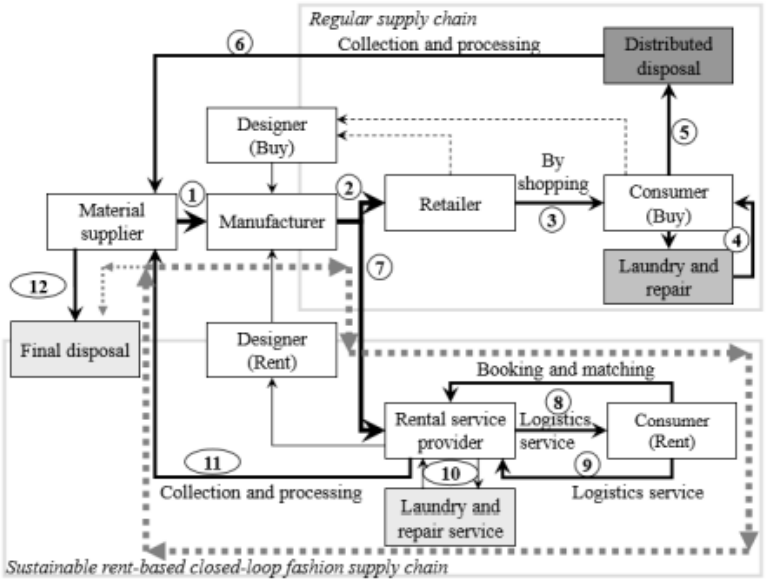

Figure 7*: A comparison between the traditional supply chain (top) and the rental supply chain (bottom). Source: Hu et al., (2014).*

The success of this model depends on the acceptance of its adoption by consumers since the system is based on the negation of the established habit of owning clothes. Companies operating in this sector are aware that the mainstream market for renting fashion has yet to be developed and are therefore committed to promoting responsible fashion consumption amongst consumers. "*With more knowledge on sustainability, acceptance of renting clothes will definitely increase. It will become the new normal, but we have to work for that.*" stated one of

the companies interviewed in the study by Adam, Strähle e Freise. Indeed, the fashion rental system, worth $1.18 billion in 2018, is expected to reach $1.96 billion by 2023 (Rabkin, 2019).

Repair

The Repair model offers the additional service of repairing purchased garments to consumers, who have easy access to a high-quality service at little or no extra cost. The model works particularly well for high quality and expensive products where customer service plays a key role: to create a personal attachment between the consumer and the product and, by extension, the brand. On the other hand, extreme durability can lead to market saturation if repeat sales do not occur due to the quality of the first purchase. Therefore, new variations need to be continuously introduced to renew consumer interest, e.g., through the addition of colours, styles, and limited editions.

Remaking

The Remaking model consists of disassembling, redyeing, or repurposing existing products or components to create new products (Ellen MacArthur Foundation, 2021a). It is based on the principle of creating value from waste: the three major channels of waste in the textile industry include post-industrial textiles (discarded offcuts); pre-consumer textiles (returned garments or inventories); and post-consumer textiles (used clothes not suitable for reuse). In the latter case, strategies such as incentivised returns can be used in order to recover the garments, also creating a financial benefit for the consumer.

Currently, goods obtained through Remaking have a high price positioning, partly due to the additional costs of the process, partly due to the fact that they are sold as "specialty products" and therefore resold at prices with a very high mark-up.

As anticipated, in recent years, Resale, Rental, Repair, and Remaking have boomed, mostly driven by the mass market segment, which represented around 80% of total revenues, while the luxury market segment accounts for the remaining 20% (Ellen MacArthur Foundation, 2021a). The graph below shows the breakdown in terms of revenues in 2019 of these four business models.

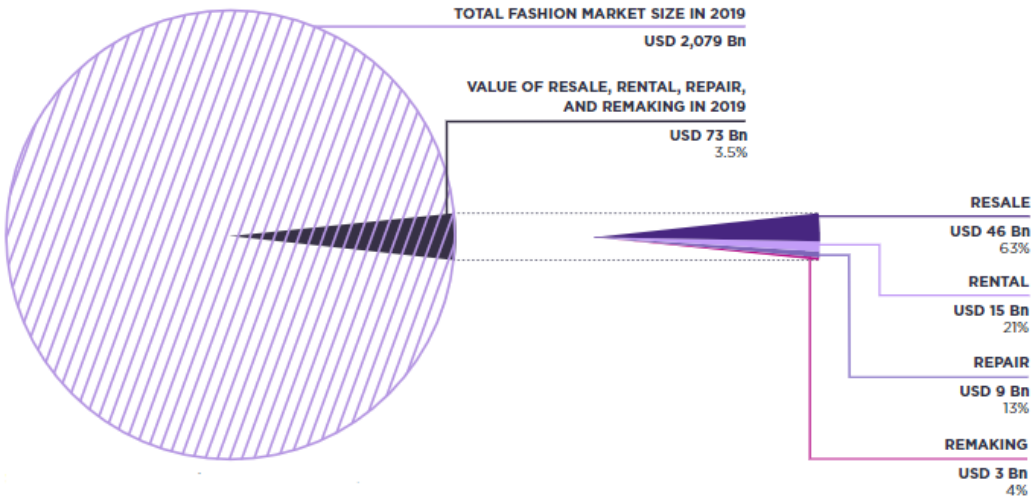

***Figure 8**: Economic value of Resale, Rental, Repair, and Remaking in 2019. Source: Ellen MacArthur Foundation (2021a).*

In 2019, Resale accounted for the largest share in terms of turnover, with around 63% of these business models, while Rental took second place, with a share of around 20%. The remaining market value was captured by Repair and Remaking, with a combined share of 17%.

Over the past two years, while traditional business models have been severely affected by the Covid-19 pandemic, which caused losses due to supply chain disruptions and strict lockdowns, Rental and Resale have shown great resilience, being able to recover quickly, and even registering significant growth. As of 2019, for example, there have been seven Rental and Resale platforms that have reached valuations above $1 billion (Ellen MacArthur Foundation, 2021a).

Chapter II – Sustainability in the textile industry: the denim market

2.1 Characteristics of the fashion industry

In 2021, the revenue of the global apparel market was approximately 1.55 trillion U.S. dollars (Statista, 2021). Although it is classified as a manufacturing industry, it differs from manufacturing products, in the strict sense of the term, because of the creative and highly intangible value of the fashion goods, the functional use of which takes a back seat, thus falling within to the so-called creative industries. The major outputs of the creative industry are intangible, experiential, and symbolic in nature. On an individual level, buying fashion satisfies deep emotions and desires such as expressing one's identity, demonstrating one's preferences, and communicating one's lifestyle. On a social level, fashion reflects the aesthetic, economic and political changes of different historical and cultural realities. The fashion context is further differentiated by its being a mature industry and a global market characterised by strong competition, short life cycles, high price pressure, high volatility on the demand side, low predictability and high impulse buying (Adam et al., 2018). The industry is further distinguished by its peculiar nature of speed, variety, seasonality, complexity, and dynamism (Čiarnienė & Vienažindienė, 2014). These characteristics make it unique, as Godart states: "*Fashion is unique because there is no other industry where change is so clearly inscribed in, and constrained by, a shared institutionalized temporal framework*" (Godart, 2018).

2.2 The environmental impact of the textile industry

Fashion production and consumption have taken on exponential proportions compared to previous decades (see Figure 9): in the last fifteen years, production has doubled and is projected to triple by 2050 compared to today, with total sales increasing to 160 million tonnes of clothing (Ellen MacArthur Foundation, 2017). These predictions are dictated by multiple factors: global population growth, estimated at 9.7 billion people by 2050, up from 7.9 billion today (Worldometer, 2022); an increase in the middle class and per capita wages in developed economies; but above all, a significant reduction in product lifecycle duration, an inevitable

consequence of fast fashion's new perspective on clothing and its emphasis on planned obsolescence (Hu et al., 2014).

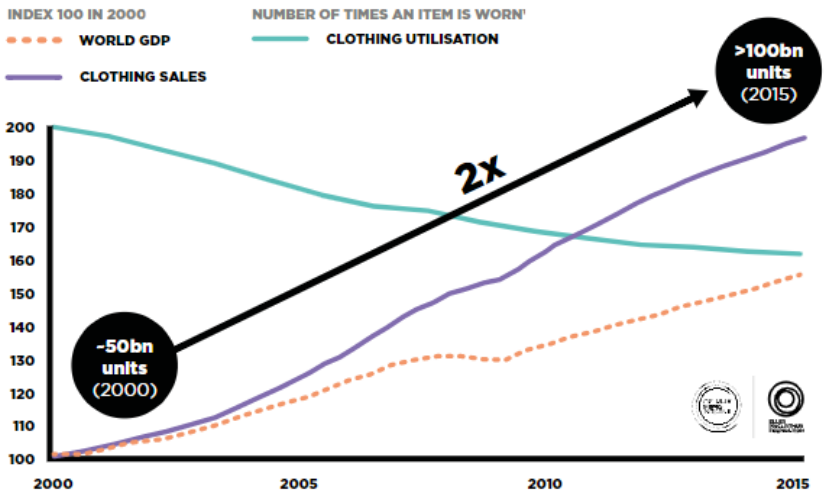

***Figure 9**: growth of clothing sales and decline in clothing utilisation since 2000. Source: Ellen MacArthur Foundation (2017).*

In fact, the number of uses of a garment has dropped by an average of 36% compared to 15 years ago, especially in richer countries. In China, a country that has seen exponential growth over the past decades, the amount of time a good is used has dropped by 70% (Ellen MacArthur Foundation, 2017).

Figure 10 below shows the reasons why garments are thrown away: the main reason (42%) is that the garment no longer fits well, other reasons are that the garment simply no longer pleases (26%) or is no longer needed (7%). Only 19% of products are considered no longer usable because they are damaged, stained or ruined.

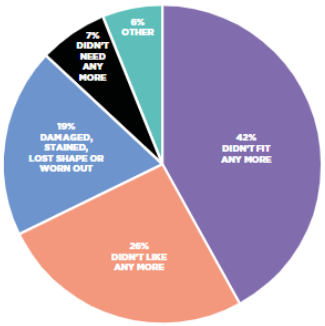

***Figure 10**: Reasons for disposal/donation/sale of clothing. Source: Ellen MacArthur Foundation (2017).*

The analysis shows how the logic of continuous substitution characterising fast fashion products, while improving the quality of life, worsens the environmental situation (Hu et al., 2014), producing more waste than traditional industry.

The above statistics inevitably call into question the future tolerability of such a system and place the fashion industry at the centre of a defenceless debate. Trends in the fashion industry and, more generally, in the western philosophy of consumerism, have in recent years had to face the opposite trends of the current natural reality. In fact, a global climate crisis has been declared, requiring profound and urgent economic, social, and political changes. The textile industry cannot exempt itself from this great responsibility, as one of the major representatives of the problem.

As far as production is concerned, the textile industry is one of the most resource depleting sectors: in Europe, it ranks fourth for consumption of raw materials and water, preceded by food, housing and transport (BOF & McKinsey & Company, 2021). Complicating its position is the fact that the textile industry mainly uses non-renewable resources (98 million tonnes per year) including oil to produce synthetic fibres, fertilisers to grow cotton, and chemicals for the production, dyeing and finishing of fibres and fabrics, to which 20 per cent of water pollution is attributable (Ellen MacArthur Foundation, 2017). In this way, the industry contributes to the spread of pesticide-borne diseases among agricultural workers and has led to the destruction of ecosystems on a large scale (Ellen MacArthur Foundation, 2017).

In addition, fashion is estimated to be responsible for 4% of annual global greenhouse gas emissions, of which more than 70 percent come from production processes (BOF & McKinsey

& Company, 2021). Under its current trajectory, the fashion industry will miss the COP26[1] goal of securing global net-zero carbon emissions by 2050 and keeping the 1.5-degrees Celsius limit on global warming within reach, as shown in Figure 11 (McKinsey & Company & Global Fashion Agenda, 2020). Therefore, many companies have already committed to reduce their emissions, and to use more sustainable materials, which are recycled and recyclable, hence playing a key role in achieving these goals.

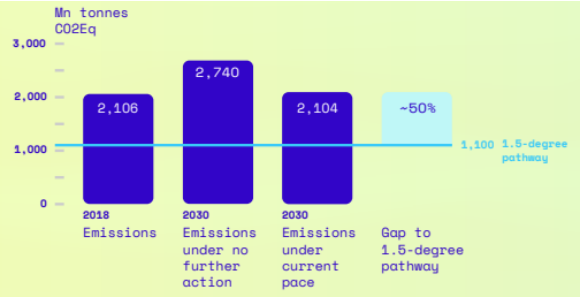

***Figure 11**: Emissions abatement assuming no further action or industry decarbonisation continues at current pace. Source: McKinsey & Company & Global Fashion Agenda (2020).*

As for the final disposal phase, at the end of the product life cycle, more than 70% of the annual textile production ends up in landfills and incinerators (Ellen MacArthur Foundation, 2017). However, it is estimated that 95% of the thousands of tonnes of textiles thrown away each year could be reused or recycled (Ellen MacArthur Foundation, 2017). Currently, this is only done for 13% of the total input, mainly for other industries and for lower-value applications (insulation material, rags, and mattress stuffing). Less than 1% of garments are reused for new clothes, creating a loss of more than $100 billion in materials each year (McKinsey & Company & Global Fashion Agenda, 2020).

In this context, recycled materials count for less than 10% of the global textile market (Textile Exchange, 2021), and are mostly produced through the open-loop recycling of plastic bottles, a system much criticised for breaking the well-established closed-loop process of recycling plastic bottles into other plastic bottles (Malik Chua, 2020).

[1] The Conference of Parties (COP) is an annual event that brings together world governments to discuss about climate change and how countries are planning to tackle it. The 26th summit was held in Glasgow, England, from 31 October to 12 November 2021.

Open-loop recycling consists of transforming waste products into new products, which will be cheaper and have a shorter life cycle, due to the presence of contaminants that reduce the value of the final product or the materials they are made of. Most of the time, materials in an open loop cannot be recycled more than once. Paper, for example, loses its durability as its fibres shorten each time it is recycled, and plastic, due to its weak polymers, can usually only be recycled once or twice into a new plastic product. Open-loop recycling, therefore, simply delays the moment when a material inevitably ends up in landfills.

In contrast, closed loop recycling aims to avoid landfill altogether, so the potential recyclability of a given product both at the design and production level. However, not all materials can be processed repeatedly without degrading, so the closed loop process is not applicable in all circumstances. In fashion, this means implementing a garment-to-garment system, in which both post-production and post-consumer textile product waste are transformed into new textile products so that the materials remain in constant circulation (see Figure 12).

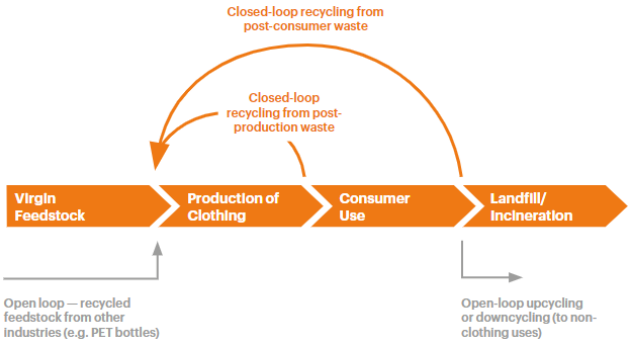

***Figure 12**: Open loop vs. closed loop recycling. Source: BOF & McKinsey & Company (2021).*

In the transition towards closed-loop systems, institutions and legislative bodies play a key role. In this regard, the EU's Circular Economy Action Plan includes the goal of ensuring that circular economy principles are applied to textile manufacturing, products, consumption, and waste management (European Commission, 2022), and the EU's Waste Directive Framework requires countries to separate all textile waste by 2025. At the same time, extended producer responsibility schemes have been implemented by several European nations that make brands and retailers responsible for post-consumer waste, and requiring producers to financially contribute for the collection, recycling, and reuse of products (European Parliament, 2020).

However, these regulatory instruments are not enough if they are not translated into effective actions at company level. Despite the considerable technological progress made in recent years, there are still many challenges that brands have to face in order for an effective large-scale transition to more closed-loop systems to take place (see Figure 13).

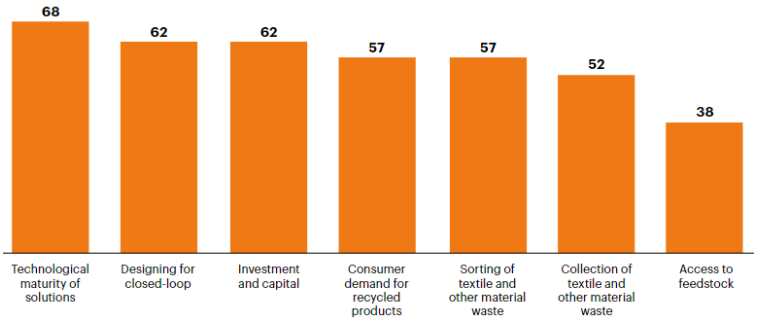

***Figure 13**: Most important factors to effectively scale closed-loop recycling, % of respondents. Source: BOF & McKinsey & Company (2021).*

Mechanical cotton recycling, through which cotton is shredded into reusable fibres, has been in place for a long time, and for others non-blended materials, a number of industrial-scale solutions are starting to enter the market, with further capacity on the way. For example, Renewcell, a Swedish textile recycling company, is building the first full-scale commercial clothing recycling plant that will be able to recycle 60,000 tonnes of textiles a year (Textile Technology, 2021).

However, a large proportion of garments are made from material blends such as cotton and polyester, which make them difficult to separate, and despite the success of some projects in this field, experts generally agree that closed-loop recycling will not reach its full potential unless products are specifically created for that purpose, for example by facilitating easier material separation through design.

For this reason, some parts of the industry are converging towards common design standards, as was the case with the Jeans Redesign Project, launched in 2019 by the Ellen MacArthur Foundation to develop some shared guidelines for the design of jeans that last longer, can be easily recycled, and are made in a way that is more sustainable for the environment and the health of workers in the industry. By May 2021, 80% of the project's participants had made fabrics or jeans that complied with the guidelines (Ellen MacArthur Foundation, 2021b).

Furthermore, larger-scale collection and sorting would help recycling facilities in processing waste more effectively. To this end, authorities, waste companies and brands are working to develop solutions: the world's first industrial-scale, fully automated textile sorting facility opened its doors in 2020 (WRAP, 2021), and in the same year an automated sorting machine that can sort around 900 kilograms of post-consumer textiles per hour was also launched (Innovation in Textiles, 2020). Some companies are also leading the way in innovative digital solutions to manage material flows, such as a digital platform that matches textile waste from sorters with recyclers, or the use of digital identifiers to encode detailed information about materials into products (BOF & McKinsey & Company, 2021).

While these initiatives show the industry is making progress, some issues remain to be solved. The often-great distance between the source of the feedstock and recycling facilities is one of them, leading to significant emissions resulting from long-distance transport. Other environmental challenges include greenhouse gas emissions and significant water use, with some critics suggesting that the reduction in impact from closed-loop processes will not be enough to slow down fashion's negative impact on climate change (Roberts-Islam, 2021). However, when compared to the open-loop— or indeed linear— models that characterise the current system, closed-loop processes are a crucial part of a wider system change for circularity.

2.3 Market for denim and today's status

The denim industry is the most segmented in the apparel sector, and over the last decade has faced strong competition from substitute products such as cargo, khaki trousers, and cotton combat. The sector also suffered a decline in sales in 2005, due to the overproduction of clothing in developing countries. Especially in these countries, the crisis has prompted manufacturers to develop new fabrics and patterns, renewing denim design, which now include the widespread use of patches, rhinestones, appliqués, and sparkles, as well as dry foam finish, flat mercerized, tinted, pigment blotch (Sharma, 2017).

The worldwide denim business sector is expected to steadily growth over the next few years, up to a value of $87.4 billion in 2027 (see Figure 14).

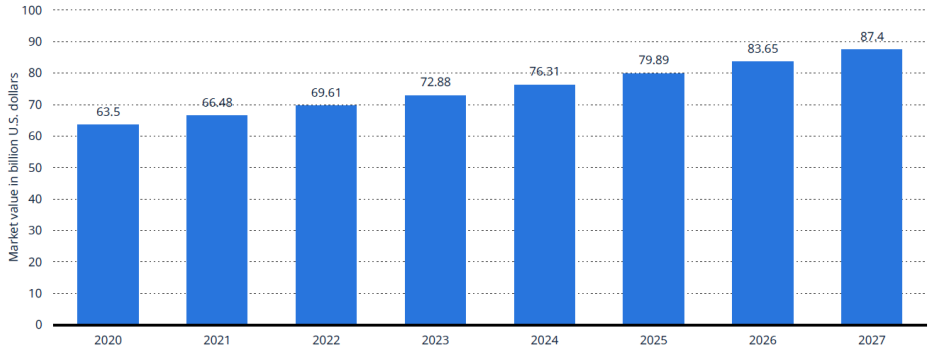

***Figure 14**: Value of the denim jeans market worldwide from 2020 to 2027 (in billion U.S. dollars). Source: Statista (2021).*

In this context, the Asian denim market accounts for around 50% of the world denim output, with a large proportion of it produced in China and India, representing a threat for established companies such as Levi Strauss & Co. In fact, it has been calculated that world demand for denim will increase by 5%-6%, while supply will increase by 8%; it will therefore be a buyer's market, where price will be the determining factor.

The fast growth of the denim market can be attributed to several factors amongst which the easy availability of raw material, rise in the disposable income of the consumers, adaptation of western lifestyle, growing working population, expanding e-commerce, and increase in the initiatives taken by the government towards the manufacturing of denim, in the countries like Vietnam, China, and India.

2.3.1 What is denim?

Denim is a material known for its robustness, and because of this quality, it was originally used to make work trousers. Over time, the use of this fabric spread until today it is used everywhere in the world to make all kinds of garments such as jeans, jackets, shirts, bags for men and women of all ages.

Denim is a very durable 100% cotton material, normally used to make jeans, suits, and other garments. Its robustness is due to its weave which is not simple, but the weft (flat strings) goes under two or more warp strings (vertical strings) to create a diagonal "twill" weave – as shown in figure 15.

Figure 15*: Denim under the microscope. Source: Wikipedia.*

Indigo denim is the most common and well-known denim, in which the weft threads are white, and the warp threads are dyed in the typical navy blue, resulting in a twill with parallel lines running from corner to corner. As a consequence of this type of weaving, one side of the material is ruled by the blue twist strings and the opposite side is overwhelmed by the white weft strings. It is for this reason that Levi's are white on the inside. Furthermore, the characteristic blurry appearance of denim is given by the indigo coloring process in which the center of the twist strings remains white.

Denim owes its name to the French city Nîmes. This fabric was already being produced in the city in the 15th century and was called *serge*[2] *de Nîmes*, which became "denim" in English. The word "jeans", on the other hand, derives from the French expression *bleu de Gênes*, i.e., blue from Genoa, because this good was exported through the port of Genoa, Italy.

Initially used for workwear, denim is now a universal fabric, that has even entered the world of high fashion. Everyone has at least one item of clothing made from this fabric in their wardrobe. The same denim initially used for jeans and overalls worn by workers in the mines on the West Coast of the United States, thanks to the addition of innovative components and modifications in spinning, weaving, and finishing, has now become a symbol of design.

2.3.2 Types of denim

As mentioned above, what has distinguished denim from the very beginning is the use of indigo-blue threads which, interwoven with white threads, gave the fabric its unique appearance. However, today in some cases, white strings are interwoven with threads of a color other than indigo, allowing this fabric to be offered in a multitude of shades. Furthermore,

[2] *Serge* is the french word for "twill"

although the first denim was a 100% twill material, today it is often produced by mixing different materials. It is therefore possible to distinguish five different types of denim (Sharma, 2017):

1. **Dry denim.** Dry or crude denim is mostly used in premium denim lines and represents a niche in the industry. Unlike washed denim, it is not washed after its dyeing. In fact, denim is generally washed after being made into a garment to make it softer to the touch and to prevent it from shrinking due to washing after purchase. In addition, non-dry denim is sometimes industrially "troubled" in order to obtain a ragged appearance. However, the same effect can be achieved over time through the use of the garment, the nuances of which will be determined by the individual's body and activities in daily life. For this reason, many denim lovers prefer this type of denim, refraining from washing the product for more than six months, achieving a unique and distinctive look.

2. **Selvage denim.** Selvedge denim (also called selvedge) is a type of denim whose edge is perfectly regular and does not come off. Prior to the 1950s, denim was produced on old-style transport looms, which weave fabric with one continuous cross thread (the weft) that is passed back and forth all the way down the length of the bolt, producing strips of heavy, tightly woven fabric. Since the edges come out of the finished loom, denim produced on this type of loom is referred to as "self-edge", hence the name "selvedge" denim. As demand for denim increased, companies began to use modern looms, which can weave larger portions of fabric at a lower cost. In this case, the edge of the denim comes out of the loom unfinished and has to be sewn, leaving the denim vulnerable to fraying. Normally, selvedge edges will be located along the outside crease of the jeans, visible when turning up the sleeves, as they are typically sewn with green, white, chestnut, yellow or red coloured hued string to separate the fabrics.

3. **Stretch denim.** Stretch denim is composed of 98% cotton and 2% spandex, a synthetic polyurethane fiber used to stretch fabrics. The presence of spandex makes the fabric more comfortable to wear, offering support in "trouble spots" such as the hips or thighs. Therefore, this type of denim is rapidly growing in the production of women's jeans.

4. **Poly denim.** Poly denim is a term that is used to refer to products that are made with a mix of cotton, polyester, and other artificial fibres such as lyocell and nylon. The poly blend is for those who are looking for a lighter denim that wash and dry rapidly, and although, as a rule, this speaks to a somewhat more established business sector, lately it

is increasingly being used for more elevated looks, intended to be “dressy but easy-going”.

5. **Ramie cotton denim.** Ramie is a vegetable fiber, very similar to silk, which gives the fabric luster and reduces wrinkles. However, its extraction process is particularly complex, which makes it particularly expensive. Moreover, it is not as solid as cotton and is therefore mixed with it to be used as denim. Depending on the percentage in which the two materials are present, a wide assortment of blends can be obtained, the price of which can vary enormously.

2.3.3 The manufacturing of denim

The denim manufacturing process is similar to that of woven (or grey) fabric up to the weaving step, with the key distinction being that denim fabric is colored at the sizing stage, whereas grey fabric's dyeing stage is determined by the type of the finished product.

The flowchart showed in Figure 16 represents the different phases of the process, the main ones of which will be examined.

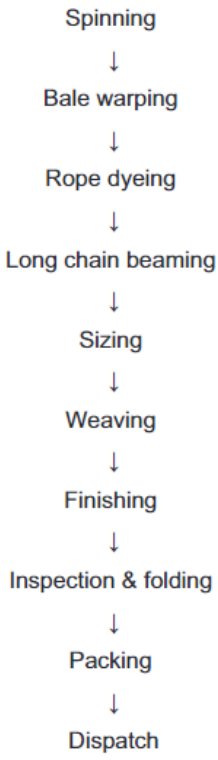

***Figure 16**: Flowchart of denim production. Source: Sharma (2017).*

Spinning

After the cotton has been harvested and cleaned, spinning is the process by which the fibers are transformed into yarn. This can take place through two methods: ring spinning and open-end spinning. Ring spinning was the method used until the 1970s, when it began to be replaced by open-end spinning, also called “rotor spinning”. In recent times, however, with the increasing demand for “authentic” denim, ring spinning is once again becoming the most widely used method. Both methods involve two steps: in the preparation phase, the fibers are parallelized and elongated, in order to obtain a durable and resistant yard. Next, the actual spinning takes place, where the fibers are twisted around each other. In open-end spinning, the drawing process happens only once, while in ring spinning the yarn is twisted multiple times, and this results in a denim with a surface intrigue that cannot be accomplished with conventional open-end yarn.

Dyeing

The process of adding color to yarn is called dyeing, which consists in soaking the yarn in a liquid containing a dyestuff. As anticipated, for denim, the most used dyestuff is indigo. Only the warp yarns are dyed while the weft yarns are left naturally undyed or bleached, which explains why denim is blue on the front and white on the back. Industrial-scale indigo dyeing consists of what is known as “continuous dyeing ranges”, in which yarns are gathered in ropes or stretched into sheets and passed through several dye baths. The former is referred to as “rope dyeing” and the latter as “slasher dyeing”.

Weaving

Technically speaking, weaving is the process of interlacing two sets of yarn at a fixed 90° angle. In a weave, the two sets of yarn fulfil distinct functions: the yarn that runs horizontally, also known as the weft, filling, or pick, is threaded over and under the yarn that runs vertically, also known as the warp or ends.

There are two types of technologies available for weaving machines:

- Traditional shuttle weaving system using ordinary or automated looms.
- Shuttleless weaving system using air jet, water jet, rapier, or projectile.

Today, the shuttle loom is an outdated technology, due to its slow speed and excessive machine wear and tear.

Finishing

Fabric finishing is the last stage of denim manufacturing before it is subjected to quality control and then packaged and shipped. This is where the last details are reviewed, which can make a big difference in how the fabric looks, feels, and fades.

Fabric finishes are classified into two types: functional finishes are intended to remedy and avoid dimensional stability concerns, while creative finishes enhance the look and feel of the fabric.

2.4 Key sustainability issues of denim industry

Denim is one of the major sectors of the textile industry, and jeans are the most worn item of clothing in the world.

According to the report "*The true price of jeans"*, released by the Dutch bank Abn-Amro in cooperation with the NGO Impact Institute, 4.5 billion pairs of jeans were sold in 2018 alone (Impact Institute, 2019).

The American Chemical Society has calculated that, between cotton cultivation, dyeing and denim processing, the production of one pair of jeans consumes more than 2,500 gallons of water, almost half a kilogram of chemicals (in the form of dyes, auxiliaries and finishing agents) and a huge amount of energy for irrigating the cotton and subsequent processes such as spinning, weaving, processing, and sewing (Sharma, 2017). Multiplying these figures by 4.5 billion— the number of jeans produced worldwide every year — will give an idea of the environmental impact of this garment.

Based on the three sustainability pillars of social, environmental, and economic sustainability, sustainability issues of the denim industry may be divided into five broad categories, as illustrated in Figure 17.

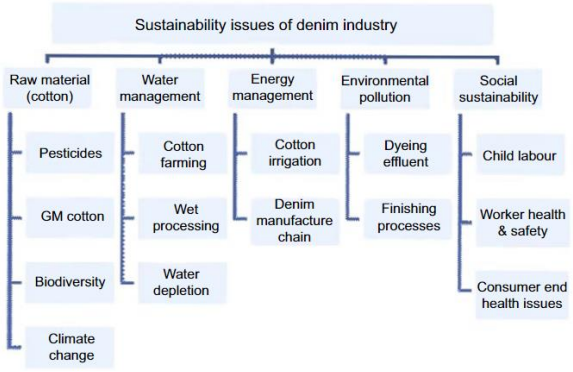

***Figure 17**: Sustainability issues of denim industry. Source: Sharma, 2017.*

1. Raw material (cotton)

The manufacture of denim consumes 35% of the world's cotton production each year. Cotton is a natural fiber grown in more than ninety countries, used in the production of clothing and household textiles for its softness, strength, and absorbency. The key characteristic of cotton is its biodegradability, however, the addition of contaminants such as dyes means that when denim microfibers come into contact with the environment, they simply settle on natural sediments (Athey et al., 2020).

Cotton farming necessitates the use of pesticides, which endangers human health and the environment. According to a study by Allen Woodburn, more than 10% of pesticides and roughly 25% of insecticides used globally are used in cotton cultivation (Allen Woodburn, 1995).

The insecticides and pesticides employed are dangerous in nature and endanger world freshwater supplies. The International Cotton Advisory Committee highlighted the environmental consequences of improper pesticide usage (International Cotton Advisory Committee, 2015):

- Contamination of drinking water, river systems, groundwater, and aquifers.
- Poisoning of fish and other aquatic organisms and biodiversity loss.
- Long-term persistence in soils impacting rotational crops and beneficial soil organisms and loss of ecosystem services.
- Poisoning of wildlife (including birds and bees) and biodiversity loss.
- Poisoning or contamination of livestock.
- Reducing populations of pollinating insects important for crop yield.

- Air pollution.

2. Water management

In the pyramid of water-consuming textiles, denim occupies the first position. Water use for the production of denim includes the production of cotton fibres, wet processing and, at the consumer end, washing. Cotton farming water requirements vary depending on several factors, including the cultivated variety, the length of the growing season, the temperature, the number of daylight hours, the amount and distribution of precipitation, the irrigation technique, and the soil's properties.

Cotton is considered one of the nine thirstiest crops: approximately 3% of global irrigation water is used for cotton cultivation. However, the relationship between cotton yield and water use appears to be linear (Sharma, 2017). This means that if water is not wasted and an equal amount of water is replenished over time, the irrigation process would be sustainable. However, water scarcity is not the only problem of cotton irrigation, as it is also associated with detrimental effects on local freshwater resources, such as eutrophication, salinization, pollution, wild-life contamination, a rise in water tables, and habitat degradation. Additionally, traditional denim (indigo) dyeing involves up to 15 dyeing vats containing potentially hazardous chemicals. Other operations, like sizing, bleaching, and denim washing, need a significant quantity of water.

3. Energy management

In cotton farming, energy is used, either in the form of electricity or fossil fuels, to run tractors, irrigation pumps, harvesting machines, etc. Only 10% of the energy employed in cotton production is used during the ginning process, with the other 90% being used on the farm. More electricity is then consumed in the subsequent spinning, dyeing, finishing, and sewing processes.

4. Environmental pollution

Ecological and toxicological problems caused by the direct discharge of textile effluents into natural water bodies are one of the most important water pollution problems.

The use of natural or synthetic indigo dyes and sulfur dyes for dyeing the warp yarns used in the production of denim generates textile effluents containing dyes that make the water toxic and unfit for human and animal consumption, and cause an imbalance in the food chains

of various aquatic ecosystems. Five heavy metals (cadmium, chromium, mercury, lead and copper) were found in 17 of 21 water and sediment samples taken in the Xintang and Gurao areas of China. In one sample, cadmium exceeded China's national limits by 128 times (Sharma, 2017). Depending on the nature and complexity of the dyes and chemicals in the effluent, systems can be used to treat and recover the dyes/chemicals and reuse the water.

Additionally, in the finishing stage of denim, there are many polluting processes: the pumice stone, which is used to wash denim garments, requires an enormous amount of water for repeated washing cycles, as well as causing environmental pollution; the abrasive material used for sandblasting, mentioned above, pollutes the environment; chemical washing, such as bleaching, uses chemicals such as sodium hypochlorite or potassium permanganate, which are harmful to human health.

By carrying out a life-cycle assessment, Levi Strauss & Co. studied the impacts of a pair of Levi's 501 jeans on climate change and calculated carbon dioxide emissions throughout its life by a cradle to grave approach. As showed in Figure 18, the consumer phase emissions were found to be the highest, followed by the fabric production phase.

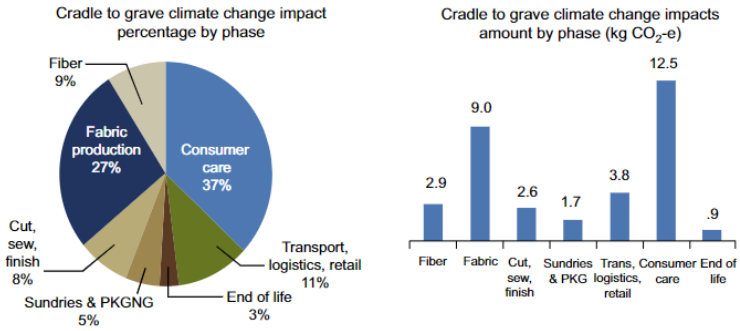

***Figure 18**: Levi's 501 jeans: climate change impact. Source: Levi Strauss & Co., (2015).*

5. Social sustainability

One of the main problems in the textile industry in terms of social sustainability is the exploitation of child labor. Child labour is used in the cotton fields for various jobs, including the application of pesticides. Children are often the first victims of pesticide poisoning, especially those living near the cotton fields, sometimes as a result of reusing empty pesticide containers.

More generally, cotton farmers around the world:

- lack safety awareness.
- lack the use of protective apparatus.
- are illiterate.
- use pesticides with poor labelling.
- practice inadequate safeguards.

Various forms of occupational illnesses have been found to constitute a risk in the textile sector. Byssinosis, often known as "brown lung disease" or "Monday fever", is an occupational lung disease induced by cotton dust exposure in poorly ventilated workplaces. Denim sandblasting, the technique whereby the denim surface is abraded to give jeans a worn appearance, has been linked to silicosis, an incurable lung disease caused by inhaling dust containing free silica. The disease proliferates rapidly under extremely high exposure conditions and continues to progress long after exposure is stopped.

2.5 Challenges and opportunities for the denim market

The previous paragraphs discussed the environmental impact of the textile industry and, in particular, the role that the denim sector plays in this context. The urgency of a change in denim production processes has emerged, a challenge that many organizations in the industry have embraced, trying to find greener strategies and new procedures to deliver a more sustainable product.

Denim organizations have offered buyers all over the world some surprising eco-friendly jeans alternatives. Some produce jeans using 100% natural cotton, others employ distinctive indigo colors, and others use bamboo for jeans.

One jeans manufacturer in Sweden tried to reuse 1600 tons of material in new garments, saving 50 million liters of water during the production of jeans (Sharma, 2017). Another jeans' brand uses only waste cotton and recycled water bottles in production. Each pair of these jeans contains eight to ten used bottles and cotton scraps collected from the floors of the production plants, which are generally thrown into landfills. This demonstrates the organization's commitment to saving the environment and finding ways to maintain a profitable business.

The following examples show how a more environmentally friendly denim production is possible by reducing water, energy, and chemical consumption.

Archroma, a global leader in sustainable specialty chemicals, has developed a more ecological denim dyeing process that can significantly decrease these impacts. Advanced Denim technology, by using sulfur dyes that bond more easily to denim fabric, can lessen 84% of water use, 30% of energy expenditure, and 50% of electricity, and produces 25% less CO_2 emissions, compared with the usual strategies (Archroma, 2022). In fact, the procedure lowers cotton waste by 87%, which is regularly burned, adding carbon dioxide and other greenhouse gases into the atmosphere. Furthermore, around 25 barrels of dyes and a number of toxic chemicals are needed to make a single pair of conventional jeans. Instead, only one barrel and innovative eco-safe, concentrated liquid sulphur dyes are needed for the Advanced Denim process. According to the researchers, if just 25% of the jeans sold worldwide were coloured using this innovative technology, the annual water demand of 1.7 million people could be satisfied each year. Additionally, the adoption of this process would save 220 million kilowatt hours of energy, while reducing wastewater to 8.3 million cubic meters. Finally, it would prevent a significant quantity of carbon dioxide from being released into the atmosphere each year (Archroma, 2022).

In 2010, Levi's initiated the Water<Less program with the aim of reducing the water use in the finishing stage, developing twenty-one innovative techniques to eliminate, combine, or reduce one or more wet processes (Levi Strauss & Co., 2016). Later, in 2015, the programme was also extended to fabric dyeing, resulting in the development of a denim fabric that saves 65% water compared to traditional indigo rope dyeing, which corresponds to an average of 6 liters of water saved per garment (Levi Strauss & Co., 2016). In addition, in September 2010, Levi Strauss & Co. placed a global ban on sandblasting in all its product lines, to ensure that no worker faces harm resulting from exposure to silica.

At this regard, Schimper et al. (2011) found a cheaper and more efficient eco-friendly alternative to sandblasting, called "Surface activation". The concentration of indigo dye is higher on the surface than in the core of the yarn and this process takes advantage of surface activation to achieve a worn or faded appearance. This not only consumes fewer chemicals that are expensive, but results in a more durable fabric that requires a shorter washing process (Schimper et al., 2011).

One-bath enzymatic fading can replace traditional chemical bleaching to give denim a faded effect, saving water and energy. Enzymes come from renewable resources; they are biodegradable, they are flexible, and they do not harm fabric as other corrosive chemicals such as caustic soda, potassium permanganate and hypochlorite do. Therefore, they are sustainable.

Lasers and ozone treatments might be used to replace denim finishing processes like bleaching and sandblasting. Lastly, synthetic stones may be used in place of pumice stones for denim washing. In fact, even modest amounts of enzyme can replicate the effect of several kilograms of pumice stones.

Mendoza et al. investigated the use of denim fiber scraps in the synthesis of an effective and affordable absorbent for water treatment (defluorination), concluding that denim-based absorbents, besides facilitating solid waste management in the denim industry, have potential for water treatment and purification (Mendoza-Castillo et al., 2016).

Chapter III - MUD Jeans - frontrunners in circular denim

3.1 Company presentation

MUD Jeans is a Dutch denim company founded in 2012 by Bert van Son. The founder, in over 30 years working in the fashion industry, witnessed how demanding is life for factory workers and how the endless demands for material, due to exploded production, are ruining our planet. This prompted him to do things differently, starting with jeans, as the most polluting items in fashion (MUD Jeans, 2022a).

In 2013 MUD Jeans introduced "Lease A Jeans", an innovative purchasing model for jeans (see Paragraph 3.1.2). Through the lease concept, customers can borrow a pair of jeans and return it once they are done using it. Depending on the condition of the returned jeans, they are either upcycled or recycled and reincorporated into a new pair of jeans.

In 2015, MUD Jeans became one of the world's first B Corps, namely, companies that meet high standards of social and environmental performance, accountability, and transparency. B Corp Certification is a certification released by B Lab, a non-profit organization which aims to spread a new stakeholder-driven business model, based on the vision of an inclusive, equitable, and regenerative economy. To obtain the B Corp certification, a company is assessed on their overall positive impact in five areas - Governance, Workers, Community, Environment, and Customers -, and must score above 80/200. For two consecutive years, 2021 and 2022, MUD Jeans was named "Best for the World+: Environment", meaning that it has achieved the highest verified scores in the Environment area.

Today, MUD Jeans is an exemplary circular fashion company, working to accelerate the transition to a circular economy in the fashion industry.

3.1.1 Mission and strategy

MUD Jeans' mission is for the fashion industry to be driven by circular production and conscious consumption (MUD Jeans, 2021). To change the fashion industry, MUD Jeans developed a strategy based on three pillars: Circular Economy, Fair Production, and Positive Activism.

Circular Economy

A circular economy is an alternative from the traditional linear 'take, make and waste' system. In a circular economy, fabrics are kept at their highest value during use, and re-enter the production process after use, never ending up as waste (MUD Jeans, 2021).

Since day one, circularity has been at the core of MUD Jeans' business model. At the moment, their jeans are made with up to 40% post-consumer recycled cotton, the highest percentage in the sector, but the company is still trying to improve its products and making them more sustainable, aiming to introduce the first jeans made from 100% post-consumer recycled cotton. MUD Jeans' circular business model will be examined in detail in Paragraph 3.2.

Fair Production

MUD Jeans' supply chain is illustrated in Figure 19. To create a product that is good for the people and for the planet, they keep their supply chain short and build long-lasting relations with each one of their suppliers. In order to ensure a safe and healthy working environment, suppliers are asked to review and sign MUD Jeans' Code of Conduct, a document that clearly outlines the values that the company stands for, including labour rights, working conditions and ethical business standards.

Labour rights concern both the legal and human rights of workers, ensuring that the employees are treated correctly at work and that their rights are protected. As demonstrated below, MUD Jeans works to achieve full transparency across the supply chain in order to ensure that everyone involved in the making of its products is respected.

Ensuring that the people behind the product receive a fair wage can be difficult as one goes down the supply chain, especially for raw materials such as cotton. In order to do so, all the actors involved in MUD Jeans' supply chain undergo regular audits to check that fair and equal pay is guaranteed to enrich the livelihood of all those working along the supply chain.

The working environment is another key topic when it comes to the wellbeing of workers, since is the place where they spend most of their time and because of the crucial impact that it can have on both physical and mental health. For this reason, MUD Jeans aims to empower the people in their factories through a safe and healthy working environment where their abilities can thrive.

Finally, as the garment industry is dominated for 80% by female workers between the age of 18 and 35, MUD Jeans believes that this industry can have great potential as an emancipating force for women worldwide, and therefore promotes solidarity, inclusiveness, and democracy, regardless of race, gender, age, shape or ability within it.

The following will describe the actors involved in MUD Jeans' supply chain, analysing their processes.

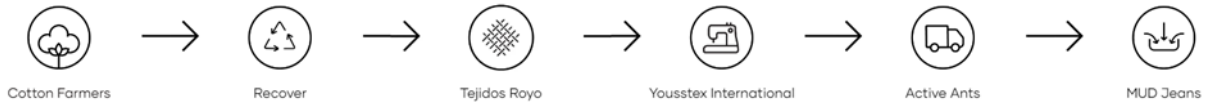

Figure 19*: MUD Jeans' supply chain. Source: MUD Jeans (2022c).*

1. Cotton Farmers

MUD Jeans' denim consists of 25-40% of post-consumer recycled cotton depending on the style, which is supplemented by organic cotton. Organic cotton is cultivated without the use of herbicides, pesticides, and insecticides. The plants are non-GMO, and the ground on which they are grown on is toxins-free and is given time to recover in between harvests. In order to guarantee that the cotton comes from sources where no toxic chemicals, pesticides, or genetically modified seeds are used, all the virgin cotton that MUD Jeans uses in its production has the Global Organic Textile Standard (GOTS) certification.

The GOTS certification is an internationally recognized standard for the sustainable processing of clothing and textiles made with organically grown fibres, that ensures that the cotton has been harvested with the highest environmental and social standards. In fact, to make the items truly sustainable, GOTS has strict standards for the whole supply chain: products must contain at least 70% of organically grown fibres, only low-impact chemicals are permitted, there are stringent restrictions on wastewater treatment, and target goals and procedures to reduce water and energy consumption are required. Additionally, social criteria based on the key norms of the International Labour Organization must be met, including safe working conditions, no discrimination, and no child labour. Every stage of processing, manufacturing,

and wholesale must be independently certified, and regular inspections are also carried out by independent third-party certifiers along the entire textile supply chain.

While not having direct contact with the farmers who grow and harvest the cotton, through the GOTS certification, MUD Jeans knows that it comes from Izmir, Turkey. There, the cotton is picked by a farmer that must be certified according to national or international farming standard, and only then it can be sold to a GOTS certified trader. At this point, the cotton is cleaned to remove seeds and other residues, brushed, and processed into a thick string-shaped "carded sliver". The organic cotton thus obtained is then mixed with recycled cotton fibre by Recover.

2. Recover

Since 1947 the fourth-generation family business Ferre has been pioneering the production of sustainable materials. In 2006, Ferre gave a name to its recycled product line: Recover, a name that reflects their process and their commitment to sustainability.

By working with brands and companies around the world, Recover collects fabric waste in order to recycle it into a high quality, low-impact fibres that can be used again to create new garments, closing the loop on fashion. Their yarns received the highest score in the Higg Material Sustainability Index, certifying that they meet the Zero Discharge of Hazardous Chemicals and REACH compliance standards[3].

Recover recycles three categories of textile waste: post-industrial, pre-consumer and post-consumer (Recover, 2022). Post-industrial textile waste, also called "scraps" or "clips", refers to excess fabric generated at any point in the garment manufacturing process, and is often the easiest type of fabric to recycle, as it has no elements such as buttons or zips to remove. Pre-consumer textile waste are finished garments that could not be used or sold, mostly generated by overproduction, such as faulty goods or overstock. When they are not sold before the end of the season, these items go directly to landfill. Lastly, post-consumer textile wastes are clothes that have been worn and discarded by the end-user.

[3] Zero Discharge of Hazardous Chemicals which is an organisation dedicated to eliminating hazardous chemicals and implementing sustainable chemicals in the leather, textile, and synthetics sectors; REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry.

The main steps of the innovative Recover process are briefly described below.

Cutting. Once textile waste is submitted, all non-textile elements are removed, and large pieces of textile waste are cut into smaller ones, suitable for subsequent cleaning and shredding.

Treatment. The textile is cleaned, and an antistatic spray is applied.

Shredding. The small pieces of textile waste are processed inside the shredding machine, until they resemble a bluish version of fresh cotton. The machine optimization formula is owned and for exclusively use of Recover. Mechanical recycling shortens the filaments of recycled cotton, therefore in order to ensure the best quality, the fibre is mixed with virgin organic cotton fair (MUD Jeans, 2022c).

Packing. Lastly, the fibres are spun into new yarn, and ready to be integrated into the supply chain of MUD Jeans.

Thanks to this innovative process, for every kilogram of recycled cotton produced, 14740 litres of water, 56 kWh of energy, 23 kg of Co2 emissions, 1.1 kg of pollutants, and 10.5 square metres of land use are saved (Recover, 2022).

3. Tejidos Royo

Tejidos Royo is a Spanish company founded in 1903, leader in the textile industry in Europe, with clients in more than 30 countries, who value the company for its innovative products and attention to their social and environmental impact. The team is considered the main asset of the company, as many employees have their roots embedded in the company since generations.

Here, MUD Jeans' yarn is dyed, and the fabric is woven into denim fabric using innovative methods which allow to save on water, chemicals, waste, and energy. Specifically, Tejidos Royo incorporated sustainable solutions like wastewater treatment plants - to ensure the water they use is cleaned - and a co-generation station to be energy self-efficient.

At the moment, Tejidos Royo is using two types of dyeing techniques: C2C indigo dye and the Dry Indigo Process. Both techniques employ no harmful chemicals and are designed to safeguard the people and the environment. All the water used in the dyeing process of the denim is cleansed and purified before being released into the environment.

After being dyed, the yarns are woven into a fabric cloth, and MUD Jeans takes care of performing a quality check before shipping the fabric to its denim manufacturer Yousstex International.

4. Yousstex International

Here, the fabric is cut, sewn, washed and branded.

The factory is located in Touza, a rural area of Tunisia. Its founder, Mr. Habib Mansour, wanted to revolutionise the denim industry. The philosophy of Yousstex International is well summarised in its mission statement: "*Humanising the jeans production by introducing the smiles behind the seam while producing jeans in an innovative and sustainable way*" (Yousstex International, 2022). Of 550 employees working at the fabric, 400 are women, making it a place of women empowerment. This is reflected in the union representatives of Yousstex, 70% of which are women. All employees are entitled to three weeks of paid leave and can receive complimentary medication if necessary. In addition, all employees are given free transportation to and from the factory (Yousstex International, 2022).

For what concerns the innovative processes used by Yousstex, is worth to mentioning the reverse osmosis, through which the company recycles 95% of the water used in the production by filtering all indigo and fibre residues out of the water. The remaining 5% of water evaporates, leaving a residue that is used to make construction materials (MUD Jeans, 2022b).

Moreover, the e-Flow technology is an innovative approach which allows Yousstex to sustainably achieve the abraded effect of the jeans, by replacing the traditional process with nano bubbles made of natural chemicals, water, and air. This allows to cut down the use of 5% on water, 10% on chemicals, and 40% on electricity (MUD Jeans, 2022b).

Finally, instead of the traditional use of sandpaper and the chemical potassium permanganate, Yousstex is giving to jeans the same worn effect by using a specific laser that burns off the yarn and makes the white core of it visible. Thanks to this technique, not only the damages to the fabric are reduced, but also dangerous manual labour and the use of harmful chemicals is prevented.

5. Active Ants

Active Ants, a Dutch e-fulfilment company specialised in cross border e-commerce logistics, is MUD Jeans' logistic partner.

The company uses an Autostore storage bins system, counting more than 100,000 bins, where products are stored in a highly compact manner, reducing their footprint at the minimum. As soon as an order comes in, Autostore robots retrieve the right bin and deliver it to the picking operator, who can then easily take the right product out of the bin, thus maximising time and minimising the risk of errors. Once the item has been collected, automated packaging machines pack products in a tailor-made packaging, choosing from more than twenty different types of boxes, padded envelopes and shipping bags, thereby minimising the amount of wasted space and materials (Active Ants, 2022). At this point, the product is ready to be shipped to the buyer, who can choose from a wide range of shipping methods and options.

6. MUD Jeans

MUD Jeans' headquarter is based in Laren, Netherlands, in "De Groene Afslag", a sustainable meeting and working space surrounded by nature. Here, is also located MUD Jeans' first lease shop, where consumers can try on the jeans and receive personal fit advice by someone from the team.

Positive Activism

The last pillar of the MUD Jeans strategy is *Positive Activism*, which consists of sharing knowledge with consumers and other brands, to show them how recycling jeans and using innovative production techniques is possible and inspire them to do the same.

MUD Jeans pursues this objective through various communication channels, including Instagram, Facebook, LinkedIn, and Twitter, sharing its journey at speaking events - such as the Circular Design webinar and the Circular Economy Forum -, and participating to various statement campaigns like the World Water Day, and the Fashion Revolution Week, an annual seven days campaign that brings together all fashion activists to collectively reimagine a just and equitable fashion system (Fashion Revolution, 2022).

For its most loyal customers, MUD Jeans also activated the Ambassador Program: by completing various tasks - including referring MUD Jeans to a friend, writing a product review, posting on social media platforms pictures wearing MUD Jeans products, etc.-, the Ambassadors earn points and gets rewarded, receiving discount codes, gifted products, and first access to new collections. In this way, not only does the brand build a long-term relationship with its consumers, but thanks to them it also gains new clients and visibility.

From the site, it is also possible to access the MUD Jeans Knowledge Centre, a platform offering various free content for all ages, from the Supply Chain Game textbook, to discover playfully how to create new jeans from old ones, to the Student Kit, a comprehensive kit with all necessary information and resources about sustainability and the circular economy, to the Sustainable Fashion Course (MUD Jeans, 2022d). Here, the recordings of the Circular Q&A can also be found, a Zoom session hosted every month by the CEO Bert van Son to answer questions to anyone interested to understand what the circular economy embodies and how this can be transformed in a business model.

To make the change happen faster and on a larger scale, MUD Jeans partnered up with several other disruptors, B Corps, and environmental and social companies to share their overlapping philosophies to each other's audience. A few examples are presented below.

Justdiggit is an international NGO, founded in the Netherlands that believes in nature-based solutions to tackle climate change. Their work is focused on regreening dry lands with ancient techniques, modern technology, and a strong communication approach, helping degraded areas return to their green self (Justdiggit, 2022). The restored trees help retain water and capture Co2, having a positive impact on biodiversity, climate, agriculture, and local communities. MUD Jeans and Justdiggit are collaborating to drive positive impact: for every returned pair of old jeans, MUD Jeans will donate the funds needed to re-grow a tree in Dodoma, Tanzania.

Sea Shepherd is a non-profit, marine conservation organisation, whose mission is to end the destruction of habitat and wildlife in the world's oceans, in order to protect ecosystems and species (Sea Shepherd, 2022). In 2019 MUD Jeans teamed up with Sea Shepherd to create a capsule collection to raise awareness of the importance of conserving the ocean and protecting the planet for future generations. The profits of this collaboration go to Sea Shepherd to support their continuous and important mission against illegal fishing and plastic pollution.

3.1.2 "Lease A Jeans"

MUD Jeans is known for its innovative "Lease A Jeans" concept, that offers users the opportunity to lease a pair of jeans for € 9,95 per month. After one year, the payments stop automatically, and the customer can decide to keep the jeans, or return them and switch to a new pair starting a new lease for €8,95 per month. The returned pair is upcycled into vintage

jeans or recycled as a resource for new denim. When starting the leasing, the client can send to the company an old jeans and get a 1 month discount; additionally, during the leasing period, customers can enjoy free repair services. Also, the client can lease a second jeans paying €8,95 per month.

This new concept has advantages both for the producer and the consumer. On one side, MUD Jeans can ensure that once the jeans have been worn out, they do not end up in landfill, but become raw material for new products; on the other side, the consumer can enjoy a fashionable and ethical pair of jeans, made through great materials and fair wages.

In 2020, MUD Jeans sold 45,000 pairs of jeans and 8900 were sent to be recycled (MUD Jeans, 2021). However, before achieving these results, the project encountered several difficulties. Initially, the company not only doubted the acceptance of recycled jeans by consumers, since many consumers associate recycled products to second-hand products and are not willing to pay premium prices, but also the recycling technology. After several technology hurdles, the company managed to develop some innovative methods —non-harmful, eco-friendly, and bio-degradable chemicals— to replace the use of potassium permanganate (PP) spray (Thatta & Polisetty, 2022). Furthermore, MUD Jeans are stonewashed, and laser techniques and ozone for washing reduce water consumption. All these inventions drive up the price of recycled fabric, which, compared to that produced by traditional methods, is 25% higher due to the premium rates resulting from the use of skilled labour (Elander et al., 2017).

3.2 The MUD Method

Keeping in mind the principles of the Circular Economy, MUD Jeans developed a simple but effective recycling format called the MUD Method, a ten-steps action plan to produce the most basic clothing— a pair of jeans— in a sustainable way.

1. Recycle

Even though the process of recycling is more expensive than producing using only virgin cotton, the company inclines towards recycling as they save natural resources. At present, the company's products contain up to 40% of post-consumer recycled cotton. Despite this being the highest percentage in the market, the company aims to launch the first jeans made from 100% post-consumer recycled denim.

"Road to 100" is a project in partnership with Circle Economy[4] with the aim of producing a pair of jeans that is 100% made from post-consumer recycled cotton. The project began in 2019 and completed the first pilot testing in 2020. The second pilot testing began in 2021 and ended in June 2022 with the production of first sample 100% made from worn garments. The old fibres have been chemically recycled using a nonharmful material called NMMO that dissolved the cellulosic material of old jeans into a pulp (MUD Jeans, 2022e), subsequently used to make the yarn. Through a Life Cycle Assessment estimation, the company calculated that this new fabric would reduce Co2 emissions by 23%, and water consumption by 76% (MUD Jeans, 2021). Now the company is working to scale things up and make it into production to finally sell on the market the first 100% recycled denim.

2. Fair Production

Paragraph 3.1.1 already extensively explained the procedures implemented by MUD Jeans within its supply chain to ensure that everybody in the company and in the fabrics is treated equally, and that fair wages are paid.

In addition to what has already been said, it is worth to mentioning that MUD Jeans committed to include in its Sustainability Reports a section dedicated to diversity and inclusion to keep track and review progress on this topic. MUD Jeans also identified a few additional goals: to increase the intake of data on diversity and inclusion (both internally and in its supply chain), to incorporate diversity into marketing decisions, and to bring more information on diversity to their team (MUD Jeans, 2021).

3. Toxic-Free

The fast fashion industry is responsible for 20% of the worlds water pollution due to the toxic dyes used in the production of garments (MUD Jeans, 2021). MUD Jeans implemented sustainable techniques, eliminating PP spray, and using and eco-friendly indigo dye that is Cradle 2 Cradle certified[5]. Also, 95% of the water used by MUD Jeans' factory laundry is recycled through reverse osmosis, and its paper tags are OEKO-TEX certified, one of the world's best-known labels for textiles tested for harmful substances.

4. Transparent

[4] One of MUD Jeans' partners, Circle Economy is an Amsterdam based impact driven social enterprise whose mission is to help cities and businesses implement and accelerate circular economy.

[5] Cradle 2 Cradle assesses the material health of a product, its impact on the environment as well as its recyclability.

Transparency and traceability are two key cornerstones to build a responsible brand. MUD Jeans has full traceability of every item that goes into the making of their products, knowing where the materials come from, and who is making them. The company holds a direct relationship with its 4 main partners (i.e., Recover, Ferre, Tejidos Royo, and Yousstex International), frequently visiting the factories, working closely with them, and fostering supportive partnerships.

5. Seasonless

One of the major problems of the fashion industry is the need to continuously renew the offer in the shops, to the point of producing six collections per year. MUD Jeans rejects this mechanism, producing styles that are seasonless and made to last. Therefore, they mostly offer classic fits, and only occasionally add a new fashionable style or colour (MUD Jeans, 2022a).

Furthermore, MUD Jeans places orders according to a NOOS (Never out of stock) strategy, which consists of placing monthly orders based on a demand analysis for each style. Thanks to this approach, waste due to unwanted stock is avoided and a continuous, long-term working relationship with supply chain partners is promoted, with transparent prices and comfortable production times (MUD Jeans, 2021).

6. CO2 Neutral

On average a pair of jeans uses 23,45 kg of Co2e6. Compared to this value a pair of MUD Jeans avoids 74% of Co2 consumption (Vicaria, 2021). This result is attributable to the initiatives of supply chain partner regarding energy consumption, one of the biggest drivers of Co2 impact. Indeed, the energy used by Ferre in its production is 100% renewable and Tejidos Royo is energy self-sufficient through its co-generation station.

MUD Jeans has been carbon neutral since 2016, and in 2020 became carbon positive, meaning that the company offsets more Co2 than the amount that it produces. This is possible thanks to the carbon offset credit mechanism: each carbon credit is a certificate that counts the prevention or removal of one tonne of Co2 and other greenhouse gasses, coming from capture or prevent the creation of Co2. By supporting projects related to renewable energy and reforestation in South America, MUD Jeans has accumulated the credits needed to neutralise its impact and 300 tons of additional credits that gives it its carbon positive status.

[6] Co2e (the abbreviation for "carbon dioxide equivalent") is a metric used to measure and compare emissions from greenhouse gases based on how severely they contribute to global warming.

7. Send Old Jeans

Extending the life of clothes from one to two years reduces the impact on emissions by 24%. MUD Jeans gives its customers the opportunity to make this choice through its repair service and the vintage collection scheme. The former is offered free of charge for 12 months to everyone who buys or leases a product. In 2020, 101 pairs of jeans were repaired. The vintage scheme, on the other hand, is offered to all customers who return MUD jeans after use. Returned jeans that are still in good condition are washed and resold in the vintage collection.

8. Lease A Jeans

MUD Jeans is unique for its "Lease A Jeans" model, already explained in detail in Paragraph 3.1.2. By leasing a jeans for €9,95 per month the customers can enjoy the experience of owning a new pair of jeans, without experiencing the environmental anxiety of buying new clothes, while MUD Jeans stays the owner of the raw material and get them back once the consumer is done using it, to recycle it in new denim.

9. Organic Cotton

As already anticipated, is not available yet a 100% recycled denim, and therefore MUD Jeans uses for its products a blend of recycled cotton and virgin cotton. All the virgin cotton used is GOTS-certified organic. This certification guarantees that the cotton has been produced without the use of toxic chemicals, pesticides, or genetically modified seeds are used. GOTS also prevents child labour and discrimination of those involved in the growing and harvesting of the cotton. Instead, they prioritise safe and decent working conditions, as well as sustainable agricultural practices.

10. Vegan

MUD Jeans adopts a holistic approach to sustainability, caring about the environment, the people, and also the animals. Therefore, the company not only uses recycled and organic materials, but also replaces leather patches with paper and printed labels, without doing any harm to animals. "PETA-Approved Vegan" certification validates that no animal products are involved in any part of the creation of MUD Jeans.

3.3 Life Cycle Assessment

A Life Cycle Assessment or Life Cycle Analysis (LCA) is a quantitative method that helps businesses measuring and evaluating the environmental footprint of their products.

Businesses may use this data to discover opportunities to improve efficiency of their processes, reduce emissions and lead their strategy. To reduce complexity in the assessment, the analysis starts by defining which phase of the product lifecycle is assessed: raw material extraction, manufacturing and processing, transportation, usage and retail, or waste disposal. These assessments can later be linked together to complete a larger level Life Cycle Assessment (Ecochain, 2022).

MUD Jeans' first LCA, published in 2015, calculated the CO2 footprint and the water consumption of the average MUD Jeans, based on which the company has been working since 2016 to offset its total emissions (Vicaria, 2021).

With the support of Ecochain, in 2019 MUD Jeans produced the first updated LCA report, with the objective to publish a new report every year. Ecochain is an LCA research firm that conducts the analysis on a consolidated data set using the Activity-Based Footprinting methodology, resulting in a footprint at product, process, or company level. MUD Jeans asked to its four main supply chain partners to share in-depth information about every aspect and input that goes into the final product, including energy, fuel, transportation, chemicals, and water. This information was then plugged in into Ecochain platform to obtain an impact overview of each style of the collection (Vicaria, 2021) .

The 2020 LCA contained updated calculations and new production details. This study focused on calculating the impact from cotton to final piece, capturing the impact of recycling old jeans and the making of new yarn with these materials. It takes the assumption that as a circular business all jeans are returned for recycling, hence leaving out the end of life, but still taking into consideration waste generation during the production phase (Vicaria, 2021). The LCA does not capture the impact of MUD Jeans' logistics partner, and the delivery of the product to customers.

Compared with the 2019 LCA, MUD Jeans impact values have decreased significantly, mainly due to product development (such as the undyed collection) as well as improved data collection. The analysis is focused on three key areas: Water, CO2 & Biodiversity.

Water

Figure 20 shows the water consumption per jeans across the years in comparison with industry standards. The average pair of MUD Jeans consumes 477 litres of water, representing

an 18% impact reduction from the 2019 LCA, and a 93% difference compared to industry standards (Vicaria, 2021).

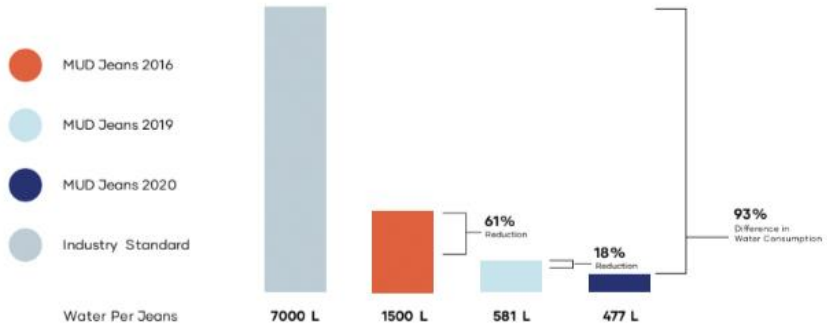

***Figure 20**: Water per jeans. Source: Vicaria (2021).*

CO2

The CO2 impact per MUD Jeans decreased in the same way that water did. According to the 2020 analysis, a pair of MUD Jeans consumes 6,10 Kg of CO2e on average, which is a 15% impact reduction compared to 2019, and a 74% difference compared to industry standards, as illustrated by Figure 21 (Vicaria, 2021).

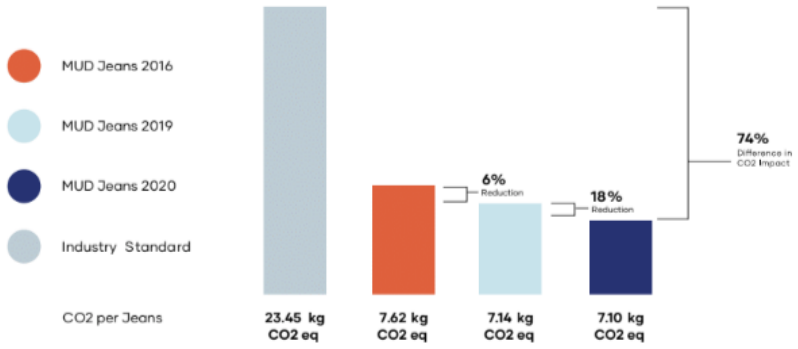

***Figure 21**: CO2 per jeans. Source: Vicaria (2021).*

Biodiversity

For the first year in 2020, the LCA analysis also includes the biodiversity impact variable, that measures the number of species lost in a year because of the impact derived from

production. Biodiversity loss has been identified as one of the most serious challenges ahead humanity in the next decade, playing a substantial role in climate change and the health of the planet (Vicaria, 2021). The fashion industry not only contributes significantly to biodiversity loss, but it also relies heavily on a healthy biodiversity balance.

According to the calculations, the average biodiversity impact per pair of MUD Jeans is 0,000000203 (2,03 E-07) species per year (Vicaria, 2021). Comparison with industry standard results complicated since MUD Jeans is the first brand to consider this variable. To make this possible, an industry standard example was built, assuming the use of 100% conventional cotton and toxic chemicals. When this industry standard value is compared to the average MUD Jeans impact value, a 51% difference in biodiversity impact is found (Vicaria, 2021).

The 2020 report also includes some scenarios depicting the impact that customers have depending on how they take care of their jeans. The difference in Co2 impact between a cold wash and washing the jeans and tumble drying them ranges from 53 to 77%, resulting in each customer contributing from 11 to 85% of the Co2 impact of their jeans over the course of a year (Vicaria, 2021). This can rapidly translate into the impact of the jeans reaching six times the original production impact value.

From the 2020 LCA, the use of virgin cotton and non-renewable energy in the final phases of production (ironing and sewing) emerge as the main areas of improvement to further reduce the impact across all styles (Vicaria, 2021).

Conclusions

Sustainable thinking, initially treated by many with scepticism as a momentary trend, is evolving into a veritable paradigm, penetrating every process and market on a global level, capable of challenging the foundations of the traditional system. Although it is now a compulsory choice, the challenge of sustainability, while generating fear due to the urgency required and the non-granted success, also represents a great new possibility.

The several initiatives taken by most companies in the fashion industry - such as the development of eco-friendly collections, the use of sustainable materials, and the abolition of the use of materials of animal origin in production- show that sustainability is a central issue in the industry today. However, these initiatives, although appreciable, are not enough to solve the environmental crisis if they are not accompanied by a change in the premises on which the entire fashion system is based, i.e., seasonality, short product life cycles, and high impulse buying by the consumer.

Therefore, a rethinking of the entire business model of companies is necessary, for a transition from a linear model, in which the resources used in production are thrown away after consumption, to a circular model, in which "*nothing is lost, nothing is created, everything is transformed*". While the concept of a circular business model has been discussed in the literature for decades now, and many theoretical models have been developed in recent years, its concrete applications are still limited.

This thesis focused its analysis on a specific sector, that of denim, one of the most polluting in the textile industry, in order to understand if and how it is possible to transform theory into practice by developing an entirely circular business model. Through an in-depth analysis of MUD Jeans, the chosen case study company, it has been shown how it is possible to produce quality denim in a sustainable way, minimising its environmental impact, without wasting natural resources, but through circular strategies that respect the planet and the people living on it.

It must be emphasised, however, that the success of such a business model is made possible by the small size of the company, which allows for direct control over the supply chain, and makes production planning based on sales forecasts possible, and guarantees a certain freedom in strategic decisions. The adoption of such a model in a larger company would

certainly be more complex and present greater challenges, an issue worth investigating in future research.

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Summary

Chapter I – From the linear model to the circular business model

Between the end of the 19th century and the beginning of the 20th century, the illusion of infinite resources resulting from the unprecedented technological progress, has been both cause and effect of the development of the linear economy, based on the "take-make-dispose" model. According to this model, the life of each product is essentially marked by five stages: extraction, production, distribution, consumption, and disposal. Hence, products have a beginning and an end, and their life ends in landfills, where the material becomes waste, unusable for productive purposes.

It is clear that a development model that envisages unlimited growth in consumption is opposed to the concept of sustainability, which is why the linear economic system went into crisis in the second half of the 20th century, precisely with the emergence of energy crises and pollution phenomena on a global scale. It is now recognised worldwide that such a use of resources, combined with constant population growth, increasing consumption and often inefficient use of resources, is no longer sustainable. The fundamental need to find an alternative to the traditional growth model has originated the debate on circular economy.

It is difficult to trace the concept of Circular Economy back to one single date or author, however, practical applications to modern economic systems and industrial processes date back to the 1970s (Ellen MacArthur Foundation, 2013b).

The idea of a circular system was first presented in 1966 by economist Kenneth E. Boulding, which describes the earth as a closed and circular system with limited assimilative capacity and inferred from this that the economy and the environment should coexist in equilibrium (Geissdoerfer et al., 2017). In 1971, the biologist Barry Commoner introduced the concept of "closing the circle", contributing to the development of the idea of a circular system. A few years later, the architect Walter Stahel published a report in which the issue of the waste of resources linked to the rapid disposal of consumer goods was analysed (Stahel & Reday, 1976). In this report, a description of a new economic model that differed from the linear economy appeared for the first time: the loop economy. In those same years, the concept of "Regenerative Design" was born by Professor John Tillman Lyle , who challenged his students to envision "*a community in which daily activities were based on the value of living within the limits of available renewable resources without environmental degradation*" (CalPolyPomona,

2022; Lyle, 1996). The environmentalist Paul Hawken, along with other authors, described how economic and environmental interests can be pursued through the same principles: increasing the productivity of natural resources; using biologically inspired models and materials; moving to a business model that provides services instead of products; and, finally, reinvesting in natural capital so as to continually restore the resources found in nature (Lovins et al., 1999). In the 90s, McDonough and Braungart developed the *Cradle to Cradle* philosophy, in opposition to the linear *Cradle to Grave* model that dominates the modern industry, that focuses on improving the positive impact of products. Throughout the twenty-first century, ideologies in favour of decoupling economic growth from resource and energy consumption have spread, giving rise to sustainable development models.

The most widely accepted definition of the Circular Economy is the one provided by the Ellen MacArthur Foundation, a non-profit organisation working since 2010 to spread the Circular Economy at international level, which defines it as "*an industrial economy that is restorative by intention. It aims to enable effective flows of materials, energy, labour and information so that natural and social capital can be rebuilt*" (Ellen MacArthur Foundation, 2013b). Analysing the literature on Circular Economy, three main "actions" emerge, namely the 3R's Principles: Reduction, Reuse and Recycle (Ghisellini et al., 2016). These principles can be integrated by three additional principles (Ellen MacArthur Foundation et al., 2015):

- Principle 1: *Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows*.
- Principle 2: *Optimise resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycle*.
- Principle 3: *Foster system effectiveness by revealing and designing out negative externalities.*

The principles described above represent a guide to the implementation of actions oriented towards circularity. From these it is possible to derive some milestones that summarise the various theories from which the Circular Economy originates (Ellen MacArthur Foundation et al., 2015): Design out waste; Build resilience through diversity; Shift to renewable energy sources; Think in systems; Think in cascades.

For Circular Economy to find concrete application within the current economic system, it is necessary for companies to implement radical changes in the management of production processes, as well as in the actual production phase. In general, Business Models define the

organisational and strategic solutions that enable a company to create and distribute value while gaining a competitive advantage (Baden-Fuller & Morgan, 2010). The term "Business Model Innovation" refers to a new way of creating and capturing value, achieved by changing one or more components in the business model (Frankenberger et al., 2013). At the same time, an innovative business model can only be defined as such only if it is perceived as new by customers. In this respect, the development of new Business Models within the Circular Economy, as an economic model based on sustainable growth, can be considered a case of innovative strategy. A Circular Business Model exploits the reuse and recycling of resources, both with a view to saving resources, and thus costs, and reducing environmental impact.

According to a study published by the Ellen MacArthur Foundation, Circular Business Models can be grouped into three categories (Ellen MacArthur Foundation, 2021a): More use per user; More users per product; Beyond physical products. Accenture has identified within these categories five underlying business models driving the Circular Economy (Accenture, 2014):

1. Circular Supplies: provide renewable energy, bio based, or fully recyclable input material to replace single-lifecycle inputs.
2. Resource Recovery: recover useful resources/energy out of disposed products or by-products.
3. Product Life Extension: extend working lifecycle of products and components by repairing, upgrading, and reselling.
4. Sharing Platforms: enable increased utilization rate of products by making possible shared use/access/ownership.
5. Product as a Service: offer product access and retain ownership to internalise benefits of circular resource productivity.

The results of the Accenture study are in line with those presented by Geissdoerfer et al. (2020) who, based on an in-depth literature review, outline four general strategies for circular business models:

1. Cycling: materials and energy are recycled within the system, through reuse, remanufacturing, re-furbishing, and recycling.
2. Extending: the use phase of the product is extended through long-lasting design, marketing, maintenance, and repair.

3. Intensifying: the use phase of the product is intensified through sharing economy solutions or public transport.
4. Dematerialising: product utility is provided without hardware through substitution with service and software solutions.

Focusing on the fashion industry, four main Circular Business Models characterise the sector (Ellen MacArthur Foundation, 2021a):

1. Resale: consists of the sale of second-hand garments.
2. Rental: consists of offering the consumer the possibility of renting a product, of which the company retains possession and is responsible for maintenance upon its return.
3. Repair: offers the additional service of repairing purchased garments to consumers, who have easy access to a high-quality service at little or no extra cost.
4. Remaking: consists of disassembling, redyeing, or repurposing existing products or components to create new products.

Chapter II – Sustainability in the textile industry: the denim market

Fashion production and consumption have taken on exponential proportions compared to previous decades: in the last fifteen years, production has doubled and is projected to triple by 2050 compared to today, with total sales increasing to 160 million tonnes of clothing (Ellen MacArthur Foundation, 2017). These predictions are dictated by multiple factors: global population growth; an increase in the middle class and per capita wages; but above all, a significant reduction in product lifecycle duration, an inevitable consequence of fast fashion's new perspective on clothing and its emphasis on planned obsolescence (Hu et al., 2014).

As far as production is concerned, the textile industry is one of the most resource depleting sectors: in Europe, it ranks fourth for consumption of raw materials and water, preceded by food, housing and transport (BOF & McKinsey & Company, 2021). Complicating its position is the fact that the textile industry mainly uses non-renewable resources (98 million tonnes per year), and fashion is estimated to be responsible for 4% of annual global greenhouse gas emissions, of which more than 70% come from production processes (BOF & McKinsey & Company, 2021).

As for the final disposal phase, at the end of the product life cycle, more than 70% of the annual textile production ends up in landfills and incinerators (Ellen MacArthur Foundation, 2017), and less than 1% of garments are reused for new clothes (McKinsey & Company &

Global Fashion Agenda, 2020). In this context, recycled materials count for less than 10% of the global textile market (Textile Exchange, 2021), and are mostly produced through open-loop recycling, which simply delays the moment when a material ends up in landfills. In contrast, closed loop recycling aims to avoid landfill altogether, hence the potential recyclability of a given product both at the design and production level. Some critics suggests that the reduction in impact from closed-loop processes will not be enough to slow down fashion's negative impact on climate change (Roberts-Islam, 2021). However, when compared to the open-loop— or indeed linear— models that characterise the current system, closed-loop processes are a crucial part of a wider system change for circularity.

Denim is one of the major sectors of the textile industry, and jeans - with 4.5 billion pairs sold in 2018 alone (Impact Institute, 2019) -, are the most worn item of clothing in the world. Based on the three sustainability pillars of social, environmental, and economic sustainability, sustainability issues of the denim industry may be divided into five broad categories:

1. Raw material (cotton): the manufacture of denim consumes 35% of the world's cotton production each year. Cotton farming necessitates the use of pesticides, which endangers human health and the environment.
2. Water management: in the pyramid of water-consuming textiles, denim occupies the first position. Water use for the production of denim includes the production of cotton fibres, wet processing and, at the consumer end, washing.
3. Energy management: in cotton farming, energy is used, either in the form of electricity or fossil fuels, to run tractors, irrigation pumps, harvesting machines, etc. More electricity is then consumed in the subsequent spinning, dyeing, finishing, and sewing processes.
4. Environmental pollution: ecological and toxicological problems caused by the direct discharge of textile effluents into natural water bodies are one of the most important water pollution problems, making the water toxic and unfit for human and animal consumption, and causing an imbalance in the food chains of various aquatic ecosystems.
5. Social sustainability: one of the main problems in the textile industry in terms of social sustainability is the exploitation of child labour. More generally, cotton farmers around the world lack safety awareness, lack the use of protective apparatus, are illiterate, use pesticides with poor labelling, practice inadequate safeguards. Additionally, various

forms of occupational illnesses have been found to constitute a risk in the textile sector, such as byssinosis and silicosis.

The urgency of a change in denim production processes is a challenge that many organizations in the industry have embraced, trying to find greener strategies and new procedures to deliver a more sustainable product. Denim organizations have offered buyers all over the world some surprising eco-friendly jeans alternatives. Some produce jeans using 100% natural cotton, others employ distinctive indigo colours, and others use bamboo for jeans.

Chapter III - MUD Jeans - frontrunners in circular denim

MUD Jeans is a Dutch denim company founded in 2012 by Bert van Son. MUD Jeans' mission is for the fashion industry to be driven by circular production and conscious consumption (MUD Jeans, 2021). To change the fashion industry, MUD Jeans developed a strategy based on three pillars:

1. Circular Economy: since day one, circularity has been at the core of MUD Jeans' business model. At the moment, their jeans are made with up to 40% post-consumer recycled cotton, the highest percentage in the sector, but the company is still trying to improve its products and making them more sustainable, aiming to introduce the first jeans made from 100% post-consumer recycled cotton.
2. Fair Production: to create a product that is good for the people and for the planet, MUD Jeans keeps its supply chain short and builds long-lasting relations with each one of its suppliers. In order to ensure a safe and healthy working environment, suppliers are asked to review and sign MUD Jeans' Code of Conduct.

   All the virgin cotton that MUD Jeans uses in its production has the Global Organic Textile Standard (GOTS) certification, which guarantees that the cotton comes from sources where no toxic chemicals, pesticides, or genetically modified seeds are used. The yarn is made by Recover, a company that collects fabric waste in order to recycle it into a high quality, low-impact fibres. After, the yarn is dyed, and the fabric is woven into denim fabric using innovative methods which allow to save on water, chemicals, waste, and energy. Finally, the fabric is cut, sewn, washed, and branded at Yousstex International, using innovative processes such as the reverse osmosis, the e-Flow technology, and laser treatments.

3. Positive Activism: MUD Jeans shares knowledge with consumers and other brands, to show them how recycling jeans and using innovative production techniques is possible and inspire them to do the same.

MUD Jeans is known for its innovative "Lease A Jeans" concept, that offers users the opportunity to lease a pair of jeans for € 9,95 per month. After one year, the payments stop automatically, and the customer can decide to keep the jeans, or return them and switch to a new pair starting a new lease for €8,95 per month. The returned pair is upcycled into vintage jeans or recycled as a resource for new denim. When starting the leasing, the client can send to the company an old jeans and get a 1 month discount; additionally, during the leasing period, customers can enjoy free repair services. Also, the client can lease a second jeans paying €8,95 per month.

This new concept has advantages both for the producer and the consumer. On one side, MUD Jeans can ensure that once the jeans have been worn out, they do not end up in landfill, but become raw material for new products; on the other side, the consumer can enjoy a fashionable and ethical pair of jeans, made through great materials and fair wages.

Keeping in mind the principles of the Circular Economy, MUD Jeans developed a simple but effective recycling format called the MUD Method, a ten-steps action plan to produce the most basic clothing— a pair of jeans— in a sustainable way.

1. Recycle

Even though the process of recycling is more expensive than producing using only virgin cotton, the company is inclined towards recycling, as a way to save natural resources. At present, the company's products contain up to 40% of post-consumer recycled cotton, but it aims to launch the first jeans made from 100% post-consumer recycled denim.

2. Fair Production

In addition to what has already been said, it is worth to mentioning that MUD Jeans committed to include in its Sustainability Reports a section dedicated to diversity and inclusion to keep track and review progress on this topic. MUD Jeans also identified a few additional goals: to increase the intake of data on diversity and inclusion (both internally and in its supply chain), to incorporate diversity into marketing decisions, and to bring more information on diversity to their team (MUD Jeans, 2021).

3. **Toxic-Free**

MUD Jeans implemented sustainable techniques, eliminating potassium permanganate spray, and using and eco-friendly indigo dye that is Cradle 2 Cradle certified. Also, 95% of the water used by MUD Jeans' factory laundry is recycled through reverse osmosis, and its paper tags are OEKO-TEX certified, one of the world's best-known labels for textiles tested for harmful substances.

4. **Transparen**t

MUD Jeans has full traceability of every item that goes into the making of their products, knowing where the materials come from, and who is making them. The company holds a direct relationship with its four main partners, frequently visiting the factories, working closely with them, and fostering supportive partnerships.

5. **Seasonless**

MUD Jeans mostly offer classic fits, and only occasionally add a new fashionable style or colour (MUD Jeans, 2022a). Furthermore, the company adopted a NOOS (Never out of stock) strategy, which consists of placing monthly orders based on a demand analysis for each style.

6. **CO2 Neutral**

Compared to the average jeans, a pair of MUD Jeans avoids 74% of Co2 consumption (Vicaria, 2021). This result is attributable to the initiatives of supply chain partner regarding energy consumption, one of the biggest drivers of Co2 impact.

MUD Jeans has been carbon neutral since 2016, and in 2020 became carbon positive, meaning that the company offsets more Co2 than the amount that it produces. This is possible thanks to the carbon offset credit mechanism: each carbon credit is a certificate that counts the prevention or removal of one tonne of Co2 and other greenhouse gasses, coming from capture or prevent the creation of Co2.

7. **Send Old Jeans**

MUD Jeans gives its customers the opportunity to extend the life of clothes through its repair service and the vintage collection scheme. The former is offered free of charge for 12 months to everyone who buys or leases a product. The vintage scheme, on the other hand, is

offered to all customers who return MUD jeans after use. Returned jeans that are still in good condition are washed and resold in the vintage collection.

8. Lease A Jeans

As already anticipated, MUD Jeans is unique for its “Lease A Jeans” model. By leasing a jeans the customers can enjoy the experience of owning a new pair of jeans, without experiencing the environmental anxiety of buying new clothes, while MUD Jeans stays the owner of the raw material and get them back once the consumer is done using it, to recycle it in new denim.

9. Organic Cotton

MUD Jeans uses for its products a blend of recycled cotton and virgin cotton. All the virgin cotton used is GOTS-certified organic. This certification guarantees that the cotton has been produced without the use of toxic chemicals, pesticides, or genetically modified seeds.

10. Vegan

The company replaces leather patches with paper and printed labels, without doing any harm to animals. “PETA-Approved Vegan” certification validates that no animal products are involved in any part of the creation of MUD Jeans.

Every year MUD Jeans conducts the Life Cycle Assessment or Life Cycle Analysis (LCA), a quantitative method that helps businesses measure and evaluate the environmental footprint of their products. The 2020 LCA focused on calculating the impact from cotton to final piece, capturing the impact of recycling old jeans and the making of new yarn with these materials. Compared with the 2019 LCA, MUD Jeans impact values have decreased significantly in all three key areas (Water, CO2 & Biodiversity), showing how it is possible to produce quality denim in a sustainable way, minimising its environmental impact, without wasting natural resources, but through circular strategies that respect the planet and the people living on it.