Sustainable Textiles: Production, Processing, Manufacturing & Chemistry

Subramanian Senthilkannan Muthu *Editor*

Novel Sustainable Alternative Approaches for the Textiles and Fashion Industry

Springer

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Series Editor
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This book is dedicated to:

The lotus feet of my beloved Lord Pazhaniandavar

My beloved late father
My beloved mother
My beloved wife Karpagam and daughters – Anu and Karthika
My beloved brother

Last but not least
To everyone working in making the textiles and fashion sector SUSTAINABLE

Preface

Textiles and fashion sector's environmental impacts is quite known and well received and also acknowledged by various stakeholders involved in the entire supply chain, especially the manufacturing side of supply chain. The whole textile sector is enthusiastic and optimistic to investigate novel sustainable alternatives in terms of raw materials, processes, and approaches to make the entire textiles and fashion sector sustainable. The thrust to transform the entire sector to be sustainable is the need of the hour. This broad title of novel sustainable alternatives can be split into three subtopics – novel raw material alternatives, novel process alternative, and novel alternative approaches.

This volume is dedicated to deal with the *Novel Sustainable Alternative Approaches for the Textiles and Fashion Industry*. There are 11 chapters selected and published in this book to deal around the novel alternative approaches to transform the textile and fashion sector to be sustainable.

I take this opportunity to thank all the contributors for their earnest efforts to bring out this book successfully. I am sure readers of this book will find it very useful.

With best wishes,

Kowloon, Hong Kong — Subramanian Senthilkannan Muthu

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Rethinking the Fashion Value Chain: How Reshoring Can Create a Localised Product Lifecycle and Support Sustainable Economic Growth

Alana M. James, Sophie Mather, and Kelly J. Sheridan

Abstract Historically, the UK was internationally renowned as a thriving manufacturing hub within fashion and textiles, with production being steeped in quality, heritage and craftsmanship. Although it is no longer a country synonymous with fashion manufacture, current industry activity contributes £20bn annually to the economy, with 34,045 businesses in operation, employing 500,000 people across manufacturing, wholesale, and retail. While this seemingly healthy industry is economically sustainable, the market continues to source products overseas, with a heavy reliance on countries such as China, Bangladesh, and Turkey. This level of global sourcing has significant environmental and social impact, the majority of which is largely unknown to stakeholders such as brands, retailers, and consumers. Despite these negative consequences, the import of fashion products continues to increase annually with £27.7bn of goods being imported in 2020, compared to £25.9bn in 2019. Meanwhile, exports remain relatively low at £8.9bn in 2020, creating a significant imbalance of the flow of goods in a post-Brexit environment.

The consumption of fashion has also continued to rise, with the UK having the highest level across Europe. Annually, consumers spend more than £45bn, catalysed by the fast, and ultra-fast fashion business models providing accessibility across multiple platforms and channels. Low costs and high volumes have decreased the consumer value of clothing resulting in short-term ownership and premature disposal. Consumer understanding of global fashion supply chains remain minimal, creating a disconnect between clothing production and consumption. The imbalance of imports and exports in the UK, coupled with increasing levels of consumer purchasing, presents a significant opportunity for future innovation. Challenging

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current systemic norms through the reshoring of production would have positive economic impact nationally, creating a thriving, sustainable industry.

This chapter challenges traditional, linear methods of overseas production and questions the reliance on overseas supply chains as opposed to more localised manufacturing options. Furthermore, it explores how advancements in technology can help fill a gap in the skilled labour force, natural resources and equipment needed for garment manufacturing at scale. Rethinking the production and consumption of fashion is long overdue, with current methods no longer practical for staying within the Earth's planetary boundaries. Radical transformation is needed, with novel and innovative solutions required to drive forward meaningful change towards a responsible future.

Keywords Reshoring · Systemic change · Sustainable business models · Textiles · Innovation

1 Introduction

Due to human and industrial activity, the earth is warming. The consequences of a 0.5 °C temperature increase can be the difference between life and death for some species and could render large areas of the earth completely uninhabitable. The evidence of climate change is already being witnessed globally: deadly hurricanes in America, wildfires across the Arctic Tundra and Artic ice sheet melt, occurring 90 years ahead of the predicted schedule (Stand.earth, 2019). However, further warming means that these events will only escalate: at 2 °C of warming the ice sheets will begin to collapse, 400 million more people will suffer water scarcity and major cities situated near the equator will become unliveable; at 3 °C of warming, southern Europe would be in a state of permanent drought and the areas burned each year by wildfires would double in the Mediterranean and sextuple in the United States; at 4 °C there would be 9% more heat-related deaths and in some places up to six climate-driven natural disasters could strike simultaneously with damages surpassing $600 trillion (Wallace-Wells, 2019).

In response to this urgent climate call, many conflicting agreements have been made in recent years to try and reduce warming levels through carbon pollution reduction. The Paris Agreement developed in 2016 states a 40% reduction in global carbon pollution to remain below 1.5 °C of warming, while the UN Fashion Charter members have agreed to a 30% reduction by 2024 (Stand.earth, 2019). However, these reductions are being challenged, with many Member States choosing to offset their carbon emissions as opposed to addressing the original cause, counteracting the potential good these global targets could have. In 2019, United Nations addressed their general assembly stressing the urgency for states to act collectively and responsibly, stating that we have just 11 years to change our ways before irreversible damage is caused to the planet through the catastrophic effects of climate change (United Nations, 2019). However, more recent reports have emphasised the urgency of such

action in what is being labelled as *The Closing Window* (United Nations, 2022), referring on the limited time remaining to make meaningful action. While the reduction amounts and timescales are disputed, what is not disputed, is the need to change to avoid horrifying environmental consequences.

Despite glamourous connotations, fashion's linear lifecycle operations and exponential growth in consumption, contributes more to climate change than aviation and shipping combined (Environmental Select Committee, 2019). The processes undertaken during the manufacture, use and disposal of garments utilises a large volume of natural resources, emits harmful, toxic pollution and generates vast quantities of both pre- and post-consumer waste. Furthermore, contemporary modes of consumption contribute to a lack of care and conservation of garments, meaning that premature disposal is prevalent within the value and mid-level markets. Consequently, fashion has been labelled as the second most polluting industry in the world, causing 8.1% of the world's total carbon emissions (Stand.earth, 2019) across the product value chain.

To meet the consumer demand for fashion, product manufacture relies heavily on global supply chains, with environmental and social compromise being common, and often required to meet short deadlines and high volumes. The consumer's desire for large amounts of clothing, purchased at cheap prices has been exacerbated by the development of the fast, and ultra-fast fashion business models, with some brands driving retail price down to just a few pence per garment. Annually, UK consumers spend more that £45bn purchasing 26.7 kg per capita reflecting the highest level across Europe. This compares to 16.7 kg in Germany, 16.0 kg in Denmark, 14.5 kg in Italy, 14.0 kg in the Netherlands and 12.6 kg in Sweden (Commons Select Committee, 2018). Consequential of cheap prices and levels of accessibility, consumer value of clothing remains low, instilling a lack of care and little incentive for maintenance, resulting in short-term ownership and premature disposal. This linear model of production and consumption is unsustainable and no longer fit for the contemporary world, with the resource of three planet earths needed by 2050 if current levels are to be sustained (Environmental Select Committee, 2019).

The vast scale of the business remains both an economic asset and a key challenge, with revenue contributing £20bn annually to the UK. However, the reliance on overseas production has imposed an imbalance between imports and exports of clothing within the market, with £27.7bn of clothing imported in 2020, while only £8.9bn exported. This presents a significant global market opportunity for future innovation, with the need to explore sustainable methods to increase UK garment manufacturing as an alternative to overseas production.

This chapter presents an analysis of the fashion value chain, highlighting key areas of environmental and social concern within current practices, from both a production and consumption perspective. It aims to challenge current thinking on sustainability and proposes possible approaches to *re-shore* textile and garment manufacture to the UK as a feasible and commercial opportunity. The integration of advanced technology within the supply chain will be integral to the success of the proposal, harnessing new manufacturing methods to restore the UK's reputation in textile innovation and offer sustainable economic prosperity.

2 The Clothing and Textile Economy

This imbalance between the planet and its human inhabitants has been labelled as the Anthropocene, a geological term which refers to the global scale of environmental changes brought about my agricultural and industrial activity. This level of human influence is said to have had a powerful and permanent impact on the history on the earth, with both technology and social change needing to be part of the future (Brooks et al., 2018).

The start of the Anthropocene has been heavily debated, with many believing it to align with the start of the industrial revolution in 1760, where the use of fossil fuels such as coal, oil and gas, became common practice. During this time, key machinery for the creation of textiles were developed such as the spinning jenny (1765), power loom (1785) and the cotton gin (1793). With industrial machinery, textiles can be manufactured in much larger quantities than before due to increased speed and efficiency. By 1870, textile manufacturing operated more steam engines than other sectors of the economy, utilising fossil fuels in preference to more traditional waterpower methods used in earlier textile mills. This shift was again an efficiency measure, as waterpower was often seasonally affected and relied on a waterside location. By the 1920s, new materials had begun to emerge and were increasingly being used for fashion purposes. Synthetic fibres such as acrylic, polyester and nylon were being widely produced, indicating the expansion of the oil industry, and signalling a shift in the use of natural, finite resources for fashion production. Before the 1980s, the manufacture of fashion and textile products were predominantly done in-country, with areas of the UK such as London, Manchester, and the Scottish Borders housing healthy production hubs, providing hundreds of thousands of jobs for local workers. However, by the early 1980s, globalisation facilitated a move of large quantities of this production to move offshore to countries such as China, aiding brands to cut costs and increase their margins. By the mid-1990s, most of the production had moved abroad and by the early 2000s, the UK clothing and textiles sector employed its lowest number of workers with only 90,000 remaining in operational mills and factories (Bearne, 2018). While offshoring may have made good business sense at the time, it brought with it a multitude of challenges, many of which were regarding sustainable and ethical practices. The economic crash and period of recession in the UK in 2008 saw a new model of consumption emerge within fashion, one that favoured large quantities of low-cost clothing in preference to quality. Fast fashion acted as a catalyst for the speed and the volume of fashion consumption, facilitated by an abundance of synthetic fibres and a cheap labour force in countries such as Bangladesh, India, China and Morocco.

Geographical patterns in overseas production can be evidenced with the growth of manufacturing regions in response to the increasing demand for large quantities of clothing at ever-cheaper prices. This phenomenon has been described as *chasing the cheap needle around the planet* (Environmental Select Committee, 2019), meaning that fashion retailers continuously seek countries with a lower minimum wage to facilitate competitively priced products in the market. However, this top-down

pressure can often result in a compromise in social working conditions and standards including forced and non-paid overtime. Working in opposition to this direction of travel from many mass-market retailers is a consumer movement which reflects a growing awareness of social and environmental impact from the fashion industry. This consumer uprising has in contrast been labelled as *chasing the ethical pound,* indicating that there is an increasing consumer demand for their clothing to be made under fair working conditions and with minimum impact to the planet. Despite this positive body of consumer action, there remains a dichotomy between fashion and sustainability, with the need for the market to grow and economic activity to expand or face an uncertain future for the industry (Brooks et al., 2018).

2.1 The Fashion Value Chain

The lifecycle of a garment is a complex system, involving many resource intensive processes, multiple geographical locations and the production of harmful emissions and waste. From concept to disposal, a garment undertakes a long and intense journey which differs significantly from product to product, each following a unique path determined by many variables. However, the intricacies of the garment lifecycle do not reflect the lifespan of a garment, nor the speed under which this process is undertaken, with a series of extremes evidenced across the fashion industry. Many variables are determined by the market sector, including price, quality, and material. These factors can also infer the intended lifecycle of the product, influencing the consequential consumer-product value, longevity and disposal methods.

The traditional fashion industry operates a very linear lifecycle, often expressed as the *make, take, dispose* model of production and consumption, and is said to no longer be fit for the contemporary world (McDonough & Braungart, 2010). This refers to the use of resources (energy, water, and raw materials) needed to create a fashion product, which is then purchased and used by the consumer, leading to the product being disposed of at the end of its desirable or useable life. This systematic approach to fashion means that value in the garment is retained for a constraint period before it is discarded by the owner. The period this linear production process occupies can again vary wildly, with fast fashion retailers such as Zara taking only five weeks from catwalk to consumer. Alternative lifecycle models attempt to prolong the lifespan and value of a garment by providing different end-of-life options to the user opposing the discarding of the garment to landfill. These options range from repurposing the garment to extend the desirability and usefulness of the product, to donating the product to charity or a friend to create a multiple ownership model and thus extending the lifespan of the garment. Unlike the linear lifecycle model, this model creates multiple ownership loops, extending the lifespan of the product to a certain degree before the product is eventually disposed of. Often referred to as the recycling model, this series of one or more loops provides the opportunity for a new usable life to be created preventing premature disposal. The final lifecycle model often discussed within a fashion context is a cyclical model

which retains the value of a product indefinitely within the lifecycle. This model adopts the iterations evidenced within the recycling lifecycle model, but instead of the product eventually ending with disposal, the circular model suggests that the material resources in the product will be reused, in one form or another, time and time again. This approach negates the additional input of raw materials, energy and water needed in the creation of new products, favouring the use of existing materials through reuse, repair or repurpose methods. The possibility of this model being applied within a fashion setting has in the past been questioned due to the limitations of recycling textile fibres, especially those derived from man-made resources. This is partially due to the energy and resource intensity required for reuse methods, but also the heavy use of mixed fibre blends in the production of mass-market fashion, deeming the disassembly for recycling purposes void.

The shape that the lifecycle model adopts can be debated; however, the systematic approach within the fashion industry remains standardised, providing the general sense of the journey a garment undertakes from the start of its lifespan to the end. Where the varying stages of the product lifecycle do differ however is in the levels of negative environmental and social impact created. From an environmental perspective, the analysis of impact will depend on two key elements: the resources needed to execute the core function (input) and the waste produced as a result of this process (output), whereas in a social context, the analysis is far more complex and subjective, void of the scientific measurement tools utilised in environmental impact. The conditions of workers within the product lifecycle often relies on in-country policies and regulations, with the governance and auditing of these standards adding further complexity to an already difficult and sensitive debate.

2.1.1 Design

Many existing lifecycle models in fashion begin with the sourcing of natural or man-made materials, indicating that this is the first stage of product development. However, with 80% of the environmental impact of a garment determined at the design phase, this model details design as the primary stage, reflective of its importance and prominence in the creation of a garment. Many of the decisions made during the creative design process create impact at later stages of the fashion lifecycle. An example of this would be the amount of microfibres a garment sheds during washing in the use phase. An estimated 6490 to 87,165 tonnes of microfibres are released annually in the UK from washing alone (Hazlehurst et al., 2023). A single polyester fleece can release between 0.95–2.47 g of polyester microfibres during a single 5 kg wash (ibid). Variables that can help reduce the amount of fibres shed include the yarn type, fabric construction methods, dyeing techniques and the application of chemical and/or mechanical finishing all of which are determined during the design phase. While this results in the designer being in a unique and powerful position to create sustainable change, it relies on their knowledge and understanding of the impact created by clothing. Although restrained by many other factors, such

as price and season, small adaptations can be made during the design process to reduce environmental impact in later stages of the lifecycle.

From a geographical perspective, the design process remains fairly contained, with many of the actions being conducted by a team within a primary location. These actions will follow the steps undertaken in the design process including primary and secondary research, ideation, concept development, design development and range planning. In isolation, these actions create relatively little impact; however, the creation of garment samples, often carried out by their supplier, create extensive waste, and carry a heavy carbon emission price tag from the shipping of products between the design and manufacturing locations. The sampling process acts as a trial-and-error process, taking garment designs from 2D graphic drawings to physical 3D forms, ensuring any production errors are overcome prior to the product going into final mass-manufacture. This process also ensures that communication between design teams and overseas manufacturers has been successful and that they have achieved a mutual understanding of the garment being produced. A series of stages are undertaken during this sampling process which creates a high-volume of products, these include initial sample, pre-production sample, size set (often two garment samples in every size offered) and final production sample (often referred to as the gold sample). This back-and-forth process facilitates comments and iterative loops, further increasing the shipping costs, emissions and the quantity of garments produced. It is estimated that £5–7bn pounds are spent on physical sampling in the fashion industry every year, with the majority of product being of little to no value once assessed by the design team. This waste product is then largely thrown to landfill or incinerated, creating negative environmental impact on a very short-lived garment (Roberts-Islam, 2019).

Advancements in technology is facilitating the digitisation of this 3D sampling process to help combat these resource intensive functions, software such as Clo-3D focuses on 3D simulation of garments to help solve any errors with fit or aesthetics prior to physical garments being produced. The use of their software aims to increase speed and accuracy, eliminating unnecessary physical sampling and shipping costs using 3D, computer generated visualisations. Similar packages are being produced by Lectra who combine software, cutting equipment, data and services to meet the specific needs of fashion. Apparel brands such as Adidas have been utilising digital prototyping for many years now, enabling them to eliminate nearly 1.5 million sample garments from their development process in just a three-year period. Likewise, American fashion retailer Target has reduced their physical sampling output by approximately 65% through the utilisation of 3D software technology (Roberts-Islam, 2019).

2.1.2 The Supply Chain

The following three stages of the fashion lifecycle: *materials, manufacturing* and *distribution*, create the garment supply chain which includes the processes accountable for the sourcing of raw materials, the manufacture of garments and the

distribution of the finished products to retail. It is the supply chain which takes a garment from an initial design idea into mass-manufacture, scaling the production from sample stage to often thousands of finished products. These three stages also document some of the most significant environmental and social impact within the product lifecycle due to many intricate operations being carried out in often multiple geographical locations. When broken down, these processes require huge quantities of resource and energy and as a result create harmful emissions and large amounts of waste. Due to the complexity and impact of these processes, many consumer action groups and non-governmental organisations (NGOs) are putting pressure on brands to be more transparent and open about the actions carried out in their supply chains. The focus of this activism is often calling for a greater level of accountability and responsibility for the standards of practice carried out in their supply chain, which requires brands to have a greater level of control and traceability of their manufacturing methods. However, due to the disconnected nature of garment workers within the supply chain, brands can pass on their responsibility for social exploitation down the supply chain to their contracted suppliers with no accountability.

2.1.3 Materials

The second stage of the fashion lifecycle focuses on materials, which documents several processes from the sourcing of raw materials to the final finished fabric ready for garment manufacture. Again, depending on the type of product being produced, this stage can vary significantly and again each and every product will track its unique journey through this stage. The beginning of this stage starts with fibre sourcing with garments most commonly being produced from either natural, man-made or cellulosic materials:

- Natural fibres – are sourced from their ecological origins, cultivated fibres such as cotton or flax will be grown in large areas of farmed land (often found in America, China, etc.), whereas animal derived fibres such as wool and silk will be obtained from the living specimens
- Synthetic fibres – are traditionally derived from finite resources such as oil (although bio-based synthetics are emerging into the market), creating plastic-based polymers produced through chemical processes and extruded in a single yarn form ready to be either combined with other materials or created into fabric
- Cellulosic fibres – created from a fibrous plant origin, cellulose (a polymeric sugar polysaccharide) forms the basis of all natural and man-made cellulosic fibres. Natural forms are vegetable, animal or mineral-based, combined with the cellulose chemical compound. Man-made cellulosic fibres (e.g. Rayon) is produced by the regeneration of dissolved forms of cellulose

Once the raw fibre has been obtained, it must be processed into a usable fibre to be utilised in the creation of a yarn. Next, yarn preparation occurs, taking the original fibre and transforming it into a useable yarn through spinning of filament and

staple fibres ready to be utilised in the construction of the material (knitted or woven). This results in the materials being in fabric greige form which can then be dyed and finished ready for garment manufacture.

The levels of social and environmental impact in this stage of the fashion lifecycle differs significantly; however, material consumption levels alone mean that substantial resource use is inevitable. By 2030, global apparel consumption is set to rise by 63% from 62 million tonnes to 102 million tonnes, which equates to 500 billion more t-shirts (Environmental Select Committee, 2019). Fibre production, dyeing, finishing and yarn preparation require vast quantities of water; however, a true assessment of environmental impact depends on the fibre, yarn and fabric preparation methods utilised. Therefore, it is difficult to compare the impact of different fibre types in a like-for like manner. However, many misconceptions exist around the positive connotations around natural fabrics as opposed to synthetic. For example, although a naturally derived product, cotton requires large quantities of water, insecticides and nitrogen rich fertilisers which increase the acidity of the soil. Polyester on the other hand, derives from petroleum, a non-renewable resource which is produced through an energy intensive process but requires relatively little water in the production process. While synthetic fibres have less impact on water and land, they emit more greenhouse gases. A polyester shirt has more than double the carbon footprint than one made from cotton (5.5 kg compared to 2.1 kg CO_2); however, the water usage in the production of one cotton shirt is between 3 and6000 L. Approximately, 60% of all fashion garments produced are made from polyester, a figure that has doubled since 2000, with exponential growth evidenced since the emergence of fashion and the growth of the value sector (Quantis, 2018). A further theoretical environmental advantage to natural fibres is that they are able to biodegrade after disposal. To add to the complexities, some synthetics can also biodegrade either as a result of a chemical interaction/modification or because of their bio-based nature (although not all bio-based synthetics are naturally biodegradable). I biodegradability of natural fibres however relies on it being used in a 100% pure form and not being utilised in mixed-fibre blends, which remains common in fashion. This is common practice as blended yarn can change the properties of the final fabric to better suit the needs or wants of the customer. This approach is also often adopted for financial reasons, commonly utilised in knitwear for example, where acrylic (a synthetic fibre) may be used for the majority of a garment for cost purposes and ease of care for the consumer, but a small percentage of merino wool (a high quality, more expensive natural fibre) may be added to make the garment feel softer and more luxurious. In this instance, the disassembly of fibre types for recycling or disposal purposes is not possible.

2.1.4 Manufacturing

Once the fabric is in final, finished state, it is transported to the garment manufacturing location, which can be a journey of many thousands of miles, again contributing heavily in carbon emissions. Overall, the fashion industry is responsible for 8.1% of

the world's total carbon emissions, a figure which is set to grow by up to 60% by 2030 (Stand.earth, 2019). The manufacturing stage of the product lifecycle transforms the fabric into the finished 3D garment, ready to be sold to the customer. The processes undertaken involve extensive human interaction, as garment construction, more than any other stage of the supply chain, requires garment workers as opposed to relying on technological advancements. The act of physically sewing a garment has changed relatively little over the past century, with many of the social issues encountered still lagging in contemporary standards. The primary functions of the manufacturing stage of the fashion lifecycle are to cut and construct the fabric pieces into garment form. Cutting fabric in mass-manufacturing is mostly automated to ensure efficiency through the cutting of hundreds of layers of fabric simultaneously and although carried out by machinery, the process will be overseen by a human operative. Again, depending on the type of garment (fabric type, construction methods and finishing techniques) the complexity of construction, machinery needed and time consumption will vary significantly. A range of operations will be conducted on a production line, which will see many workers, organised by their performing operation, working in unison. Due to the human heavy processes undertaken throughout the supply chain, social issues encountered remain common, including child labour, forced labour, excessive working hours, compulsory overtime, unsanitary and unsafe working conditions and no rights to freedom of association (being permitted to be part of a trade union). Of the 71 leading retailers in the UK, 77% believe there is a likelihood that there is modern slavery in some stage of their supply chain, with 90% of workers having no opportunity to negotiate their wages and working conditions (Environmental Select Committee, 2019).

Fashion is in the third largest manufacturing industry globally after the automotive and technology sectors, generating $2.5 trillion in global annual revenue and employing 890,000 people in the UK alone (The Business of Fashion, 2020). Unrealistic pricing throughout the supply chain is the main cause for social compromise, with fashion brands posing unrealistic requirements on suppliers to compete to offer the lowest prices, with the shortest lead times. While many fashion companies attempt to adhere to a set of responsible standards, the risk of being caught not complying to these standards remains relatively low and therefore the incentive to do so remains high (Environmental Select Committee, 2019). Non-compliance of many of these standards will help increase speed of delivery to market and quantity of garments produced. This applied pressure on the supply chain often results in compromise occurring at the expense of either the environment or garment workers. Journalist Lucy Siegle (2011) summarised this point, 'fast is not free, someone, somewhere is paying'. In response to this, it has become common practice for fashion brands to implement some level of governance in their supply chains through Corporate Social Responsibility (CSR) programmes. This begins with an assessment of a business and their customers, suppliers, communities and employees to assess their impact on society (Lindgreen & Swaen, 2010). CSR however lacks definition and boundaries, with varying levels of brand commitment to responsible change being encompassed under the same umbrella terminology (Burchell, 2008). Some companies, as an alternative to the term CSR, use terms such as *sustainable*

business practice, corporate citizenship and *corporate accountability*. However, these alternative terms take away the social meaning behind CSR, to encompass more sustainable connotations to the term. It is thought however that CSR programmes have largely failed to improve social working conditions due to their success relying heavily on auditing and compliance (Environmental Select Committee, 2019).

Traceability of garment supply chains remains a substantial social challenge within the fashion industry, with many suppliers outsourcing work to other factories to meet the increasing demand of quantity in short time frames. This again provides evidence of social compromise in the supply chain to meet the requirements of current fashion consumption levels. This new layer of suppliers, often referred to as shadow factories (Harney, 2008), presents a new set of challenges as they are not legally employed by the fashion brand, thus standards (as outlined in the CSR policy of the brand) are no longer applicable or able to be implemented. Not all manufacturing in fashion is limited to in-house factory work, but also encompasses thousands of home-workers across the global supply chain. This presents further challenges with governance and auditing, with the working conditions and safety being out with the control of fashion brand. Furthermore, who is carrying out the work being provided can also be questioned, with child labour being commonly used to again meet tight deadlines and demanding volumes of work. Despite progressive improvement in supply chain transparency in recent years, only 58% of brands reveal information about their primary tier suppliers. From the 200 fashion brands surveyed by market research agency Mintel, in 2017 only 32 brands disclosed this level of information, in comparison to 70 in 2019. However, when these figures are compared to the level of information disclosed about raw material suppliers, they begin to look positive. From the same companies surveyed, no brand disclosed any information publicly in 2017, with only ten doing so in 2019 (Mintel, 2019a).

2.1.5 Distribution

The offshoring of UK garment manufacturing has been made possible by a 90% reduction in shipping costs since the 1950s (Environmental Select Committee, 2019). Consequently, geographical distribution of garments can be a distance of thousands of miles requiring extensive transportation logistics to take the goods from one country to another. Despite the significant emissions occurred during this stage of the lifecycle, transport accounts for only 3% of the apparel industry's impact on climate change; however, this remains in a delicate balance, where shifting only 1% of transport from shipping to air-freight would cause a 35% increase in carbon emissions (Quantis, 2018).

Not all garment manufacture is housed overseas however, with Leicester in the East Midlands still operating 700 garment factories, providing work to over 10,000 local people. Despite being governed under the UK law, some of the social issues encountered in overseas manufacturing locations are also prevalent in garment

factories in the UK. Media coverage over the past few years has reported extensive *sweatshop*-like activity with unsafe working conditions evidenced by blocked fire exits and wages between £1–3 per hour (Blanchard, 2017). As a result of this non-compliance with UK minimum wage levels, owners of the factories have recently been forced to pay workers £90,000 for reimbursement of non-payments (Environmental Select Committee, 2019). Internet retailers such as Boohoo and Misguided source approximately 50% of their product from these Leicester-based factories, utilising UK-based manufacturing to increase the speed of delivery to market by producing the garment in the same country as they will be retailed. While this approach dramatically cuts down emissions from transport to overseas facilities, it does rely on social compromise to deliver very large quantities of clothing retailed as cheaply as £5 for a dress from Boohoo (Environmental Select Committee, 2019).

Transport is required at almost all stages of the garment lifecycle, facilitating the movement of goods and products from one geographical location to another. Considering a simple cotton t-shirt for example, two billion of which are bought and sold globally every year, cotton as a raw material is sourced from one of the three biggest cotton regions in the world; America, India or China. Once the cotton has been picked and put in to bales, it is ready to leave the farm and be shipped by textile mills to a spinning facility to create yarn, commonly in China or India. The yarns are then sent to a mill to be knitted into fabric. The finished fabric then travels from the textile mill to a garment factory often in Bangladesh (the largest exporter cotton t-shirts with 4.5 million employees in the t-shirt industry), India, China or Turkey. Once complete, they travel by ship, train and truck to their final point of sale, often to western, high-income countries. By the end of the product lifecycle, that garment has travelled thousands of miles, contributing heavily to the carbon emissions generated by the fashion industry.

2.1.6 Consumer Use

Once the garment has reached the point of retail, the product is ready to be purchased by customers, moving the garment from the supply chain and into the consumer use phase. This stage of the fashion lifecycle utilises large volumes of energy and water due to the washing and drying methods implemented by individuals in their homes. While in the possession of the consumer, 75–80% of the overall lifecycle impact of a garment is created (Treehugger, 2019) and 25% of the garment's total carbon footprint (Fashion Revolution, 2017). There are many variables which dictate this level of impact during washing, including frequency and temperature, with the average household in the EU doing 6.2 washes per week (European Clothing Action Plan, 2017). With this level of washing frequency, an average household utilises approximately 60,000 L of water per year, with 90% of the energy consumed to heat the water (Treehugger, 2019). A study conducted by the European Clothing Action Plan (ECAP) to investigate the environmental impact of clothing indicated average washing temperatures of European consumers being

40° C, with 43% of survey participants favouring this as their preferred setting. Additionally, 24% of participants indicated that they usually washed at 30° C and only 12% being at 60° C (European Clothing Action Plan, 2017). Many fashion brands and retailers are now using garment labelling to encourage their customers to wash at lower temperatures and less frequently, in a bid to reduce the overall environmental impact created by garment washing.

In addition to energy and water, there are other environmental considerations during the use phase, including the volume of wastewater created, which will contain chemicals from detergents and microfibres shed from the fabric. Washing detergents contain phosphates which can cause algal blooms that negatively affect ecosystems and marine life (Treehugger, 2019). To help prevent this damage, consumers can choose to use eco-friendly alternatives, which are biodegradable and phosphate free. Textile fibres—or 'microfibres' as they are now more commonly termed—is a generic term for the basic elements of natural, synthetic and cellulosic textile materials. They are very small in size, often invisible to the naked eye, and can be defined as having flexibility, fineness, and a high ratio of length to thickness. Fibres fragment from textiles during the manufacturing, consumer use and end of life phases of a product lifecycle. The consumer use phase includes general handling and wear, laundering and drying. Up to 95% of microfibres released during washing are filtered out and captured in the sludge at wastewater treatment plants, although many are released into the ocean (Ramasamy et al., 2022). These tiny plastic particles can then find themselves into the diet of marine life and eventually into the food chain of humans (Resnick, 2019). A study conducted in 2018 evidenced approximately 73% of fish caught in the Northwest Atlantic had microplastics in their stomachs (Wieczorek et al., 2018), a large proportion of which will have originated from garments in consumer wardrobes.

Researchers have attempted to determine the magnitude of the release of microfibres to the environment as a result of washing. However, quantification is challenging and often figures quoted in the media and used in reports are provided without context and create misunderstanding. One myth is that microfibre pollution is caused only by petroleum derived synthetic fibres, such as polyester and acrylic, that come from synthetic clothing (Paddison, 2016). Recent estimations believe that up to 35% of global contribution of ocean microplastics comes from clothing, meaning they are the predominant contributor. However, this overlooks the significance and prevalence of natural fibres, such as cotton and wool, in the ocean, which are often found in much greater quantities (Stanton et al., 2019; Kechi-Okafor et al., 2023). Due to their plant and animal origins, natural fibres are often thought to be harmless because of their biodegradability. However, the processing, dyeing and chemical finishing applied to natural fibres during the production of fabric means they are no longer in their natural state and therefore are not as readily biodegradable. Ecotoxicology studies indicate It is the size and shape of a microfibre that makes it dangerous to our ecosystems, not the type of fibre itself (Thornton Hampton et al., 2022).

All clothing has the potential to shed microfibres, regardless of what they are made from. The amount of fibres shed during a wash cycle can significantly vary

due to fibre type, their yarn twist structure, fabric construction methods (knitting, weaving, etc.) and dyeing and finishing processes. Washing studies have been conducted to determine the most influence variables. Garments made from cotton can shed more fibres than a polyester fleece, although not always (Lant et al., 2020). Knitted fabrics tend to shed more than woven fabrics (Balasaraswathi & Rathinamoorthy, 2022), while staple yarns tend to shed more than filament yarns (Choi et al., 2021). The introduction of mechanical finishing techniques such as brushing or peaching will likely mean increased shedding, yet the application of chemical finishes can reduce it. Lower temperatures tend to result in less microfibre release, as do shorter durations (Cotton et al., 2020). Counterintuitively, smaller wash loads increase microfibre loss, thought to be due to increased agitation of the clothing in the drum (Lant et al., 2020). However, the methodology of the studies varies significantly, the choice of textile; the load, temperature, agitation and duration of the wash; the washing method itself, be it a washing machine or small-scale simulated washing equipment; presence or absence of detergent/fabric softener; and finally, the measurement used for quantification (number of microfibres or mass loss per kg). The multitude of potential factors influencing microfibre loss makes quantification across multiple studies challenging. As such, an industry standard test methodology has been developed (Tiffin et al.) that provides reliable, comparable, microfibre loss data enabling root cause understanding. Furthermore, the data can then be used to derive reliable quantification of microfibre release to the environment through wastewater. Estimations indicate that between 6490 tonnes to 87,165 tonnes of microfibre is discharged in the UK each year from domestic washing (Hazlehurst et al., 2023).

While this level of environmental damage from one stage of the value chain is alarming, the ability to create substantial change is in the hands of the consumer, with their choice of actions being crucial in the amount of impact created. Small, considered changes in their actions such as washing less frequently at lower temperatures could significantly reduce the effect of garment maintenance. Furthermore, utilising additional products such as the Guppyfriend wash bag, which captures approximately 50% of microfibres shed during washing (Napper et al., 2020) enabling them to be disposed of responsibly rather than in wastewater. Increasing the lifespan of a garment is also said to be the most effective way to reduce the environmental impact of a garment, where if a garment is retained for nine months longer than planned, the waste and water footprint would be reduced by 20–30% (Environmental Select Committee, 2019). To facilitate this increase in garment longevity, both the consumer value of the product needs to be considered and where necessary, the extension of the usable life of the garment. Product life extension methods, such as repair or repurposing, can begin to give a garment a new lease of life, from both a practical and desirable perspective. However, this method relies on the individual having the skill, time and equipment to do so, with a lack of skill or expense said to put people off repairing their garments (Environmental Select Committee, 2019). In a recent survey issued by Mintel, gauging sustainable behaviours in fashion, 72% of participants said they had repaired a garment in the past 12 months, while 35% had made an alteration (Mintel, 2019a). While the skill level

can vary considerably between basic repairs and alterations, this research does evidence a consumer commitment to actively extending the lifespan of a product they already own.

2.1.7 End-of-Life

At the end of a garment's usable or desirable life, a consumer has a series of options in which to dispose of the item; however, responsible action at this stage of the lifecycle relies on the individual being informed of not only the range of options available to them but also of the impact of those choices. This considered action is often referred to as the three 'Rs' of fashion: reduce (the amount of clothing being purchased), reuse (garments in their original form) and recycle (by making new from old). While these are all viable options, presented in order of favour, textile recycling is the least favourable due to the energy intensive and complex processes required (Brooks et al., 2018).

As a direct consequence of significant consumption levels, 300,000 tonnes of textile waste end up in household waste every year, 20% heading to landfill while the remaining 80% is incinerated (Environmental Select Committee, 2019). However, aside from landfill, there are multiple end-of-life options for garments, reflecting the different lifecycle models previously discussed (*linear, recycling* and *circular*). Landfill is a typical disposal option for the linear lifecycle model, where a garment is made, used and discarded as waste. When considering disposal options from the perspective of a recycling lifecycle model, the options become much more abundant and varied with common methods such as donation to charity, second-hand selling or passing on to a family member or friend. Alternative methods include consumers engaging in retailer take-back schemes (where old clothing is returned to participating clothing stores), recycling and swapping with friends, family or at an organised swishing event. In a 2019 consumer survey, 72% of participants surveyed claimed they had donated to charity in the past 12 months, with 48% having purchased second-hand items. 35% stated they had sold on their unwanted garments, 19% had swapped an item, 22% had engaged in a retailer take-back scheme and 19% had rented a garment from a garment rental service (Mintel, 2019a).

Donation to charity is a heavily favoured method of disposal by society but the second-hand economy has some negative connotations often unknown to individuals. Every year, 650,000 tonnes of clothing go to charity in the UK, with 11,000 charity shops diverting 330,000 tonnes of clothing which would otherwise likely be sent to landfill (Environmental Select Committee, 2019). However, of this extraordinary amount, only 10–30% of donated clothing remains in the UK to be sold in charity shops (Brooks, 2015), with the remainder being exported to marketplaces in low-income countries, which is often the most profitable outlet from the perspective of the charity. Second-hand western clothing is seen as more desirable than in-country products, which is having a significant effect on local garment production and the economy (Brooks et al., 2018).

Textile recycling schemes are becoming increasingly available, with some areas of the UK now having a household option for textile products. Other collection methods include recycling centres and local recycling points with 90% of the garments collected being either reused (59.4%) or recycled (31.8%) (Environmental Select Committee, 2019). Clothing donation systems rely on garments being collected and taken to a sorting centre, which requires the garments to be segregated by hand into fibre type categories. While this labour-intensive system has created 1400 at UK-based sorting plants (Environmental Select Committee, 2019), it also faces several challenges including faded tags, making fibre identification almost impossible and blended fibre products, which cannot be recycled (Brooks et al., 2018). The cost-effectiveness of this systems has in the past been questioned; however, an additional charge of just one pence per garment on producers, could raise £35 million to invest in better clothing collection and sorting in the UK (Environmental Select Committee, 2019). This additional funding could aid in overcoming some of the current challenges presented in closed-loop garment recycling and help increase the overall number of garments recycled.

2.2 Fashion Consumption

Consumption levels of fashion are higher than ever before, with future predicted figures on a constant upwards trajectory. As shopping becomes ever simpler and more convenient, consumers are losing a sense of value in their purchases, with impulsive buys resulting in short-term ownership and premature disposal. It is the number of garments being produced, purchased and discarded that is thought to be the main issue when assessing the environmental impact of fashion. The ownership of garments has increased exponentially over the past two decades, which has coincided with the emergence of both the fast fashion model and the recent wave of ultra-fast fashion retailers entering the fashion market. In 2005, there was an estimated 74.3 billion items of clothing produced, in comparison to 2019, where 130.6 billion items were produced, equating to every person on the planet buying 15 garments and two pairs of shoes each (Fashion Revolution, 2020). While the reality of fashion ownership is far more imbalanced between the developed and developing worlds, this increase in production volume is driven by consumer greed and not necessity. However, this path is not showing any signs of slowing with the annual value of fashion and footwear being estimated to reach £2 trillion by 2030, an anticipated growth of £500bn in the next decade (Environmental Select Committee, 2019).

2.2.1 How We Got to This?

The escalation of fashion production and ownership has occurred over many decades and can be attributed to many contributing factors, including technological advancements, changing consumer habits and developments in the global economy. As

previously discussed, a combination of access to synthetic fibres, manufacturing being moved offshore and consequential declining prices in fashion have driven the fashion market to grow rapidly. While the invention of textile machinery during the industrial revolution provided the equipment to start manufacturing materials and garments in large quantities, it has been a shift in consumer culture which has signified an appetite for consumption at contemporary levels.

In recent history, this can be traced back to the 1950s, where high-end department stores began hosting ready-to-wear fashion shows, enabling society to buy in to these exclusive fashion collections. Before this, fashion had been made to order, produced by local tailors in small numbers, as opposed to larger quantities in a variety of sizes being accessible. The 1960s has been described as the retail revolution, with independent boutiques emerging on the UK high street, changing the retail experience from an essential to a social activity, dismantling the boundaries between work and play (Fogg, 2013). An opposite from the familiar department store, the development of the boutique culture allowed youths to express their identity and their opinions through their choices of fashion. It was also this decade where fashion photography and advertising began to play a big role in influencing consumers to buy in to certain subcultures or brands. At this stage, garments were being mass-produced but were manufactured in-country and often local to the point of retail. In 1974, the Multi Fibre Arrangement (MFA) was introduced to allow developed countries to receive imports from the developing work. From the perspective of garment manufacture, developing countries, such as Bangladesh, had the competitive advantage as their labour costs are much lower than that of developed countries such as the UK and the US. This was the start of the offshoring of garments, with textile products and garment manufacture increasingly being made overseas meaning that the price of fashion plummeted. This was also a period where brands started to copy designs from the catwalk, replicating diluted versions of luxury, catwalk fashion. It is thought that this was where the fast fashion model as it is known today began to develop, with the cost of manufacturing in decline and consumer appetite increasing. This model continued to gain momentum, with the replacement of the MFA in 2005 with The World Trade Organisation agreement which removed the quota system previously imposed. This removed restrictions on the amount of imports from developing countries and only added further fuel to the escalation of the delivery of large quantities of cheap clothing to the UK fashion market. By the mid-2000s, the fast fashion market sector dominated the industry, with traditional high-streets being predominantly occupied by low value brands and retailers. The past decade has seen fast fashion being superseded with the emergence of ultra-fast fashion, taking the speed and volume of clothing production to the extreme. These e-commerce brands retail only online to facilitate a direct-to-consumer route to market to further reduce overhead costs. This new breed of fashion retailer is again changing the retail landscape as the industry continue to evolve as a reflection of societal changes.

2.2.2 Fast and Ultra-Fast Fashion

As the fashion lifecycle continues to gain momentum, increasing the speed and volume of products being produced, fast fashion is no longer fast enough for the appetite of some fashion consumers. Ultra-fast fashion retailers deliver 1000+ new styles to market every week, offering a constant cycle of new products available to their customers. This model operates regardless of season or sales, encouraging overconsumption and a disposable consumer attitude towards clothing. The direct-to-consumer sales approach and the lack of bricks-and-mortar stores allows the price of products to also remain very low, aided further by the large volume of production per style. Furthermore, with 50% of production being based in the UK, the speed of delivery to market can also undermine that of overseas supply chains. However, fashion produced at these speeds and in these volumes, often results in social and environmental compromise, with ultra-fast retailers determined to increase the speed of the lifecycle, regardless of *cost*.

This sector of the industry also relies heavily on celebrity culture and social media influencers as their key marketing strategy, with discount codes being offered to their followers as an incentive to purchase. In return, the influencers receive commission (Fashion Revolution, 2020). While celebrity endorsement as a marketing tool is nothing new, the use of influencers begins to challenge these norms, with a celebrity status no longer being necessary to influence people's purchasing behaviour in fashion. This shift has been facilitated by society's increasing reliance on technology and use of the Internet, diversifying the way people can buy and access fashion products. Despite the use of social media in this instance having negative connotations on consumption levels of clothing, evidence suggests that social media can also have a positive impact in the growth of more responsible practices across the fashion sector. Between 2015 and 2018 the use of the hashtag for sustainable fashion (#sustainablefashion) saw an increase in use of 500% (Fashion Revolution, 2020), indicating that consumer awareness, and potentially knowledge, is growing. This was also indicated in the use of search engines, where the term also increased by 66% in 2018 alone (Lyst, 2019).

The recent emergence of the ultra-fast fashion business model is indicative of the current direction of growth within the fashion industry, an area which encourages consumers to gain momentary pleasure from a low quality, inexpensive garment before purchasing again. This target audience are fundamentally gaining pleasure, albeit brief, at the expense of people and the planet (Environmental Select Committee, 2019). With consumption levels rising and the cost of fashion falling, consumers appear to be buying more fashion items but paying a much lower price, despite the effect of inflation on material, labour and transport costs. This is reflected in the average retail price for an item of clothing which in 2005 was $16.47; however, in 2019, this dropped to $13.60 (Fashion Revolution, 2020), despite an annual inflation rate of 3% on average (Bank of England, 2020).

Although negative connotations of fast and ultra-fast fashion are to be acknowledged, a more positive perspective has been considered in terms of demographic accessibility:

> Fast fashion has allowed all segments of society, irrespective of income, class or background, to engage in hedonistic and psychogenic pleasure of fashion. At no other time has fashion been so accessible to so many people across our society. This is the power of fast fashion (Environmental Select Committee, 2019).

A growth in the garment industry has also had certain positive consequences with garment workers. This includes the economic freedom and empowerment of female workers, many of whom are primary providers within their family unit as a reflection of the gender balance of the workforce. The number of families living below the poverty line has decreased, from 44% in 1991 to only 13% in 2018. Additionally, family sizes have declined and consequently the number of maternal deaths, with individuals also living a third longer than they did in the 1980s (Fashion Revolution, 2020).

However, these positives do not outweigh the numerous negative environmental and social consequences induced by of the speed and volume required in the delivery of fast and ultra-fast fashion. This model remains an unsustainable and impractical model for the future and needs to be remodelled to reflect the increasing consumer demand for transparency and higher social and ecological standards.

2.2.3 Fast Is Not Free

In 2013, an eight-storey factory collapse in Dhaka, Bangladesh would forever change the way that the fashion industry perceived social compromise in their supply chains. On the morning of 24 April 2013, thousands of garment factory workers arrived at their machines in the Rana Plaza factory complex as usual, despite owners receiving advice to close the building the previous day due to unsafe building conditions. The pressures being placed on the factory owners to complete orders for western brands such as Primark, Mango and Matalan, were passed on down the value chain, with workers being threatened with their jobs if they did not continue to work. Shortly before 9 am, it took 90 seconds for the factory floors to give way, resulting in 1134 workers being killed, an incident that unions described as ‘mass industrial homicide’ (Safi & Rushe, 2018). The aftermath of Rana Plaza created a focus on the social standards being conducted in global supply chains, with issues such as levels of pay, building fire and safety standards and freedom of association being placed under the spotlight. Despite some progress being made in the seven years since the incident, workers continue to live in poverty, unable to afford the most basic of necessities for their families. Pay for instance, remains critically low, despite a pay increase in 2018 and 11,600 workers were arrested and threatened with their jobs for participating in strikes to fight for their right to be part of a worker’s union, otherwise known as freedom of association (Fashion Revolution, 2020). While this behaviour is often associated with the lower, value-end of the fashion market, these issues are not exclusive to fast fashion retailers alone, with luxury brands now mimicking operations and being newly labelled as *fast luxury* (Environmental Select Committee, 2019).

Fast fashion, a business model based on offering consumers frequent novelty in the form of cheap, trend-led products (Niinimaki et al., 2020) utilises high levels of resource input and results in large quantities of waste, often from garments being prematurely thrown away. As previously discussed, environmental impact can be evidenced at every stage of the garment lifecycle, although when considering this in the context of the fashion business model, the volume of garments being produced alone evidences concerning levels of resource use and waste. However, it is also the speed of production that is the biggest cause for concern, with shortcuts and compromise often occurring due to the pressures of a fast-paced delivery to market. The efforts made by numerous brands and individuals to move towards a more responsible future for fashion is often outweighed by increasing levels of consumption, with consumer spending predicted to rise from £70,456 million in 2019 to £77,637 million in 2024 (Mintel, 2019b). However, future predictions appear to be based on limitless supplies of finite resources, discarding planetary boundaries in favour of monetary profit at the cost of people and the planet. The global resource input needed in the production of fashion is immense with the annual water usage alone–more than 79 trillion tonnes. When this system input translates into an output, the waste totals 92 million tonnes created throughout the value chain. Again, this occurs at every stage of the lifecycle, ranging from poor quality seconds created in error during manufacture, to garments discarded by consumers to be worn only once to impress followers on Instagram. It can be clearly identified that a degrowth in fashion is desperately needed; however, a decline in consumption levels and thus production needs to be managed carefully to prevent damage to the social economy of the global supply chain (Niinimaki et al., 2020).

2.3 Challenging Sustainability

The boundaries of sustainability within a business context are heavily debated, with a lack of definition, parameters and regulation being often accountable for confusion and a hesitance to engage. This level of uncertainty is a cumulation of many factors, including language, terminology, limitations and the absence of unbiased governance. Further adding to the complexity of this situation is its voluntary status, with individual companies choosing whether to opt in, or opt out in the integration of sustainable values into the products they design, produce and sell to the mass market. Engagement with any level of responsible behaviour is largely subjective, relying on individual companies to develop their own response and effectively implement these strategies to fit their business.

The term *sustainability*, according to the Brundtland Report of 1987, refers to meeting the needs of the present, without compromising the ability of future generations meeting their own needs. This definition refers to not only a collective responsibility between current society and future generations of individuals, but it also

refers to sustainability as a long-term strategy for the future. When considering sustainability in the context of fashion, Rinaldi and Testa (2015) attempt to define and map common language, with the aim to show the relationship and distinction between the use of key terminology. Perceptions of *responsible fashion* indicates a series of actions that consider a breadth of stakeholders. *Sustainable fashion* is thought to focus on an individual's relationship with the environment and terms such as *ethical* referring to societal factors. Despite academic interpretation, the fashion industry has no discipline specific, definitive definition for sustainability, with thousands of interpretations rendering the term almost meaningless as it can be applied in a myriad of ways. As a result of laxed parameters, the term *sustainability* is often used interchangeably with many other phrases such as green, eco, conscious, responsible, ethical, and ecological to name but a few. When observing this confusion within an industry context, hazy understanding of terminology can often lead to misinterpretation or ineffective application of sustainable actions. Furthermore, sustainability in a business context can evoke the use of corporate vocabulary which further adds to the disengagement of individuals and complexity of dissemination to a general audience.

While the need for businesses to be responsible is not a new concept, the demand for more sustainable behaviour within a fashion context is becoming increasingly relevant, driven predominantly by the consumer. As knowledge and awareness of the environmental and social impact of fashion increases within society, so too is the pressure being placed on fashion brands and retailers to carry out their business in an ethical and *right* way. An increase in media exposure is largely responsible for heightening discussions around more sustainable ways of living, directing individuals to make sustainable choices in their everyday activities. Despite this increased awareness being generalised, fashion has come under particular scrutiny because of its historic association with the unethical treatment of people and the planet. Response to this growth in consumer demand relies on systemic change to the industry as a whole and faces many challenges in the assessment and implementation of such changes.

The rationale for engagement in responsible practices has on many occasions been questioned, often being proposed as a barrier to a meaningful response to sustainability from the fashion industry. Many companies feel like they must do *something* to keep up with their competitors, and while this may be perceived as a positive response, it can often lead to a token commitment used as a tick-box-exercise. This reluctancy to commit time, effort and financial contributions significantly impacts a company's level of engagement with responsible business values, with these actions being seen as an inconvenience. Over the past decade, many brands who have chosen to embrace positive sustainable change are beginning to see the financial and reputational benefits, including an increase in brand trust with their customers. However, until responsible business becomes conventional practice in the fashion industry, there remains many challenges and barriers to be overcome in embedding sustainability throughout global fashion supply chains.

2.3.1 Realising Sustainability

The garment lifecycle is a long and complex process, with many processes contributing heavily to the negative impact consequential of the fashion industry. From a business perspective, many companies are finding it challenging to become sustainable in all their practices across their supply chain, with materiality, production and transport inherently being heavily reliant on fossil fuel consumption. The growth in the use of man-made fibres, the volume of products being produced and the speed of delivery to market are all common issues in today's fashion industry making any level of responsibility difficult to achieve.

A common approach in today's fashion market, is for brands to select certain areas of their business to focus on in terms of sustainability, improving smaller areas, in preference to a systemic overhaul, which could be argued is the most effective method to meaningful change. These small, isolated changes come in many forms, again varying from company to company, but can range from a shift to the use of organic cotton to providing basic education to workers within their supply chain. Efforts again come in many different guises and can encompass both environmental and social aspects of sustainability, with no parameters to determine what or who is targeted in a company's efforts to operate in a better way. These voluntary pockets of activity on the part of individual companies begin to build a narrative of responsibility across the fashion industry. However, it is the parity of engagement from brand to brand which poses many future, long-term challenges going froward. Reliance cannot be on those companies which are actively engaged in making their business more sustainable, but rather a collective leverage needs to be established, with every company playing their role in a much bigger picture. It is to be acknowledged that companies, regardless of market sector, need to be profitable to operate and to ensure the future sustainability of their business. It could be argued that only once this has been achieved can a company begin to consider their actions in terms of impact to people and the planet. These activities cannot be based on philanthropy alone, especially when companies are entrenched in both a society and a market sector which relies heavily on a capitalist economic model.

The varying stages of the supply chain offer many opportunity for a business to target specific areas where they want to focus their efforts in becoming more responsible. For companies who are transitioning away from more traditional production processes, these adaptations may be small yet considered. This can range from a shift to packaging that can be recycled or using deadstock fabric in future collections to larger, more logistical changes in the supply chain such as working conditions in garment factories and the transportation method from factory to shop floor. The size of the company and the volume of their operation will distinguish the ease in which these transitions can be made, with smaller brands obviously being able to adjust their processes with more ease. However, on the contrary, it is the larger fashion brands, with longer, more complex supply chains that can make small modifications but create the biggest positive impact due to the volume of product they sell. It is these same organisations who often have the most financial means and department capacity to also action these changes efficiently. Regardless however of the

size and make-up of the company, it is the willingness to change which is paramount to implementing sustainable business practices. The value in making these changes also needs to be acknowledged by senior management with collective buy-in from workers, suppliers and contractors.

2.3.2 Responsible Fashion Practices

It was once believed that shopping sustainably was only for the elite, those who could afford to pay extra for the privilege of their products being made responsibly. The accessibility to ethical and sustainable fashion used to be perceived as one of the largest barriers to change, with mass-market consumers not having the luxury of choice when it comes to responsible values. However, this is no longer the case, increasingly so within the fashion market, with numerous high street fashion brands now committing their time and energy to create a more responsible approach to their business practices. These commitments are broad and diverse, ranging from the use of recycled plastic in their carrier bags to clothing take-back schemes, and the use of waterless dyes to producing in carbon neutral factories. In addition to the type of responsible commitment, the level of engagement from companies also varies wildly, creating further complication due to the lack of industry standards and regulations. Despite these efforts being demonstrated, many believe that lower priced retailers especially, cannot possibly be sustainable as they actively encourage negative behaviour such as over consumption and premature disposal. Again, these contrasting perspectives interpret their responsible actions to be disingenuous, perceived only as a tick box exercise. Fast fashion and ultra-fast fashion brands have come under heavy scrutiny in their pursuits to be more environmentally friendly, leading their efforts to be questioned and often accused of *greenwashing.* Defined as the use of sustainability for financial or reputational gain, false or exaggerated responsible action is seen as a form of lying or being untruthful about the activities that are being taken. It is difficult to see how some items with exceptionally low-price tags could ever have been made with low-impact materials, manufactured under good social working conditions, and still have the fashion brand make a profit. In addition to the value-end of the market being scrutinised, so too is the high-end, luxury market, with little evidence for a positive correlation between price and sustainability. When comparing the manufacturing practices of low and high-end brands, there is surprisingly little difference with many of the same operations occurring, meaning the only distinct difference is product mark-up and consequently profit. The assumption of a premium price meaning greater responsibility is beginning to be challenged by consumers, with alternative consumption models such as buying second-hand, or leasing clothing now perceived as a more sustainable option.

Despite many mass market retailers now engaging in some level of responsibility, consumer knowledge of the key sustainable issues facing fashion remains largely unknown. This confusion also extends to purchasing, with 79% of consumers stating that they find it difficult to know which fashion brands are sustainable, with a fifth of these participants believing that price is a good indicator (Mintel,

2019a). This perception not only provides evidence that consumer knowledge and awareness remains a key challenge when it comes to sustainable engagement, but it also questions the accessibility of sustainable goods to customers. Furthermore, the efficiency of a brand's sustainable communication also plays a role here, with fashion retailers needing to find a balance between greenwashing and informing their target market. Effective communication of a company's sustainable commitments (often referred to as corporate social responsibility) has been evidenced to provide a range of business benefits, with effective CSR engagement not only facilitating financial gain but also an increase in brand trust. In a recent consumer survey, Marks & Spencer is said to the most trusted high street brand by far, with 63% of participants favouring the British heritage company.

With little standardisation across the fashion market, the shape and direction that responsible business should take is entirely debatable. Terminology alone remains a challenge with again a lack of regulation, leaving the interpretation of complex concepts such as sustainability and ethics, open to individual interpretation. The scope of these challenges in a fashion context, have been widely discussed. However, the practical implementation of these values within the sourcing, production and consumption of fashion remains to be seen. The onerous appears to remain with the company themselves and their personal drive to implement sustainable practices within their business, while remaining profitable and competitive in the market. Business cannot be based on philanthropy and to enable change to be created, a move away from the outdated linear model currently shaping the fashion industry, companies primarily need to make enough money to operate effectively and to create profit for future business aspirations. Many companies are beginning to interpret what responsibility can mean for their business; however, just as with the long, complex and highly individual supply chains, sustainability does not come in a one-size-fits-all approach. It is now down to the individual brands to shape their future and begin to action sustainable change, with the most successful examples beginning to embed these principles throughout the full scope of their unique value chain.

2.3.3 Building a Resilient Future

As a reflection of the very nature of fashion, the industry is continuously changing and shifting to remain desirable and responsive to the needs of consumers. Changes in retail, manufacturing methods and design trends pose frequent challenges, where brands must adapt and adjust their practices to maintain their competitive edge. The rise in awareness and demand for more responsible principles in the fashion industry is yet another challenge for existing brands, where their response is crucial in working towards a more sustainable system. However, the fashion lifecycle is a complex series of mechanisms and processes, with no element working in isolation, meaning that meaningful change will need to be systemic as opposed to isolated instances of behaviour. The brands who are leading the way in this level of innovation are beginning to really set themselves apart from the crowd, setting a standard for industry competitors to work towards.

In March 2020, the fashion industry was posed an almost insurmountable challenge with the outbreak of COVID-19, the global pandemic which closed all non-essential stores and reduced fashion retail sales by up to 80% (The Business of Fashion, 2020). The industry had to respond in numerous ways to facilitate some level of business-as-normal in the continuation of the global fashion supply chain. As discussed throughout this chapter, the fashion lifecycle is a fragmented and fragile system relying on an undisclosed number of factors for it to function. These recent challenges have only highlighted further the delicate state of the global supply chain which is reliant on social and environmental input. A significant decrease in fashion sales brought the supply chain to a standstill, meaning garment workers were out of work, suppliers were not paid and seasonal excess stock, worth approximately £18bn was building up in warehouses (Szajna-Hopgood, 2020). As is common practice in the fashion industry, suppliers are expected to pay up front for garments costs, with payment for finished products being made by retailers after the shipment has been delivered. In anticipation of slow sales, retailers cancelled orders with their suppliers, withholding payment of $2.8bn, leaving many of the 4.1 million garment workers who for western brands with no work or wages (Roberts-Islam, 2020). Brands such as Primark, Arcadia and Urban outfitters cancelled orders with their suppliers (Szajna-Hopgood, 2020), with retailers such as New Look suspending payment to suppliers indefinitely and asking for rent holidays for their stores (Jahshan, 2020).

A report issued in response to the Coronavirus by The Business of Fashion and Mckinsey and Company states that it is the responsibility of big fashion players to set an example for the rest of the industry in their rethinking of the fashion cycle, enabling real change using new digital formats. Positioned in the context of the lifecycle, they presented a model to demonstrate several ways innovation within the supply chain has been evidenced in response to the limitations created during unprecedented times. Examples include, 3D design, video signoffs, virtual shows and social consumer selling. In addition to innovation evidenced in the existing lifecycle, alternative consumption models, leaning towards a greater sense of responsibility, are also set to grow in popularity, with resale, upcycling and recycling facilitating a shift in current levels of excess stock. While these changes have been initially actioned in response to specific circumstances, they have the potential to change the fashion industry in a more long-term sense, with new and revised ways of working becoming the new normal. While there are numerous negative connotations with change, many have deemed it as *a chance to rewrite fashion*, addressing many of the systems, process and practices that are no longer suitable for contemporary society. Trend forecaster, Li Edelkoort reiterates the need for change going forward: 'the virus I think is like our conscience, it brings light on what is so terribly wrong with society and the everyday becomes clearer, it teaches us to slow down and to change our ways' (The Business of Fashion, 2020).

For decades now, it has been recognised that the traditional fashion model is not operating in a sustainable manner, with business decisions, profits and consumer greed determining the level and rate of fashion consumption. In addition to the period of lockdown as a chance for the industry and its consumers to reflect on their

core values, it has also offered the opportunity for innovation and a new way of thinking for the fashion industry. A renewed reliance on technology has enabled methods such as virtual sampling and AI supported planning to be utilised in remote or isolated working, empowering key roles in the supply chain such as designers and merchandisers. The use of technology has been extended to the use of digital showrooms for trade shows and fashion weeks, preventing the production of millions of sample garments and travelling many thousands of miles by attendees. This provides further examples of how innovation has been born out of necessity, all of which has had a very positive impact through the reduction in energy use and waste production during sampling and a significant cut in carbon emissions from national and international travel. Furthermore, the global pandemic was said to be responsible for a recent preference to bringing production methods closer to home, often referred to as 'nearshoring' (The Business of Fashion, 2020). Whether from necessity or not, this move again has a positive potential reduction in environmental impact, with a reduction in carbon emissions created during the transportation of goods and materials in the supply chain.

Many of these chances for innovation can be interpreted as a way of futureproofing the fashion industry for any potential threats which may come in the near or distant future. Companies are now encouraged to identify, prioritise and scale-up any successful innovative methods implemented during recent periods of difficulty to be responsive in periods of flux that require speed and flexibility to survive (The Business of Fashion, 2020). The need for harmonisation within the fashion industry has been called upon, with a balance between pre and post pandemic states needing to be found.

3 Reshoring Garment Production

Despite the offshoring of garment production from the UK in the 1980s, making good business sense at the time, considerations around the return of manufacture have begun to gain momentum, with many motivational drivers being identified. Just as with many aspects of sustainability, terminology remains inconsistent, thus the practical response to such debate is often subjective and misguided. Terminologies interspersed within these debates include *backshoring* ['Re-concentration of parts of production from own foreign locations as well as from foreign suppliers to the domestic production site of the company' (Kinkel & Maloca, 2009); 'The geographic relocation of a functional, value creating operation from a location abroad back to the domestic country of the company' (Holz, 2009)], *reshoring* ['Moving manufacturing back to the country of its parent company' (Ellram, 2013)], *backsourcing* ['Production return relocation from an[…] external entity' (Holz, 2009)], *de-internationalisation* ['Any voluntary or forced action that reduces a company's engagement in or exposure to current cross border activities' (Benito & Welch, 1997)], and *international divestment* ['A reduction of ownership percentage in an

active direct foreign investment on either a voluntary or involuntary basis' (Boddewyn & Torneden, 1973)].

However, two terms that better reflect the needs of the garment industry are *new shoring* and *next shoring*, encompassing the expectations around the ability to scale at speed, while working within resource limitations of new locations. Unlike other terms, these embrace the innovation behind the approaches, adopting systemic change and true technology disruption in areas such as advanced robotics, digitalised manufacture and the optimisation of additive manufacture. Through these new ways of working there are many opportunities to considerably reduce the traditional steps required in the production of garments and as such time, cost and resource use. While onshoring challenges can be seen by some as limitations to commercial entry, these can be re-framed as innovation opportunities born out of a systemic change in use of technology and process. Although it could be argued that there are only subtle definition differences with these terms, they do focus on the step change needed from purely producing in a new country or location, to that of commercially producing to meet a consumer need within a new country or location. Furthermore, through discussions of the practical implementation of these concepts, it should be noted that 100% shift in production may not always be appropriate, with a segmented move allowing developing areas of the supply chain time to mature and scale. An example of this could be that raw materials critical to the end-product are shipped in from overseas, while textile and garment manufacture are carried out at scale within the UK. The potential these approaches provide to the design and development of clothing is significant and should be seen as a design opportunity for future fashion.

3.1 Motivations for Reshoring Production

The scale of negative environmental impact created by linear production and consumption methods within fashion is widely acknowledged. However, the relationship between reshoring production and environmental sustainability has been previously questioned with debates suggesting that this alone cannot be the rationale for such logistical upheaval (Orzes & Sarkis, 2019). Motivations to instigate reshoring of production within the context of fashion are varied and go beyond sustainability. However, the consequences of many key drivers reduce or negate social and environmental impact. The breadth of motivational factors is diverse and can often offer multiple benefits where the division between the benefits is not always clear (i.e. the introduction of a new innovation/technology, could support the boost in national economy while also offering considerable sustainability advantages).

In an extensive literature analysis conducted by Di Mauro et al. (2018), a total of 42 key motional drivers were identified for both offshoring and backshoring resulting in the development of a theoretical framework. Additionally, this considered internal and external factors within the context of perceived customer value and cost

efficiency. Key findings conclude that offshoring is often highly motivated by reducing costs, in comparison to backshoring which is said to be based more on a strategic approach (Bals et al., 2016; Mugurusi & de Boer, 2014). This is due to the facilitated collaboration between production and development functions and therefore, despite increased manufacturing costs, can be perceived as a sensible location response to the changed competitive strategy (Di Mauro et al., 2018).

Figure 1 illustrates the authors interpretation of the key motivations for reshoring production, adopting an industry stakeholder perspective. Furthermore, it seeks to propose practical solutions for implementation through clustering in four key areas:

Industry Leadership The UK can again regain its position and reputation in textile innovation and leadership within garment production, reflecting on the prosperity for manufacturing prior to offshoring in the 1980s.

– Reshoring production also boosts the national economy, increases jobs and industry revenue contribution to GDP.

Sustainability First Working through the framework of Newshoring/Nextshoring a sustainability first approach can be applied to new innovation and technology developments.

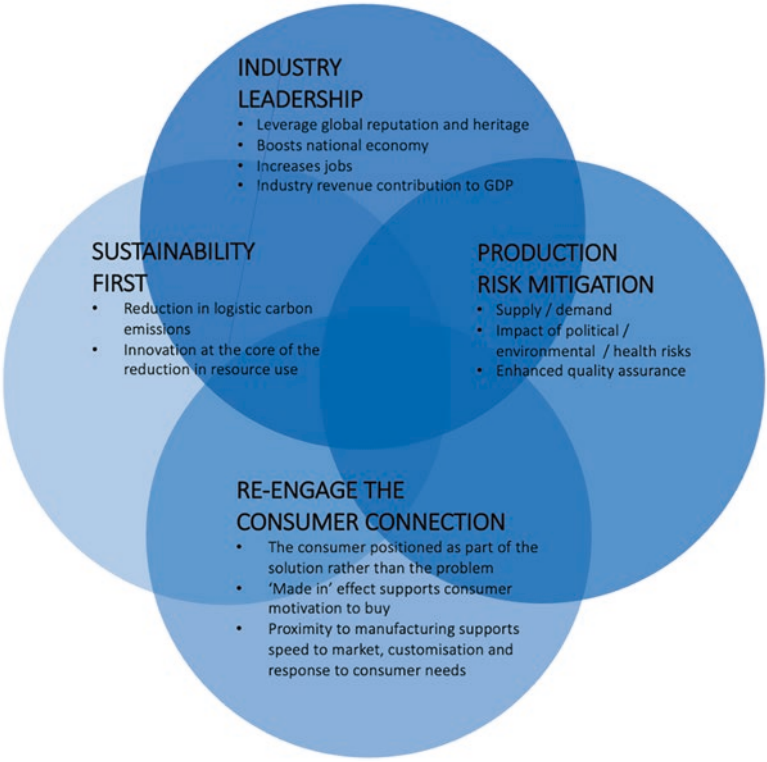

Fig. 1 Motivations for reshoring fashion and textile production. (Authors own)

– A reduction in logistical reliance can be expected as a result of a direct and significant decrease in transportation needed of goods and materials from the production location to the point of sale. Consequently, this will result in a reduction in carbon emissions from sea and/or air freight and reducing the environmental impact of the supply chain processes.
– As production embraces low resource use technologies (i.e. CO_2 Dyeing where zero water and 50% less energy is required) production facilities will be able to measure resource savings in areas such as energy, water and raw materials.

Re-engage the Consumer Connection A closer consumer connection to manufacturing can be developed, empowering the consumer to become part of the solution rather than accelerating the problem.

– The positive impact of what has been labelled as the 'made in' effect can aid in the consumer motivation to buy into a specific brand or label, providing instant insight into the origins of the product. Additionally, this could overcome the knowledge, connectivity and empathy gap identified between consumers and the supply chain (James & Montgomery, 2017).
– Enhanced trust can be built between companies and their customers facilitated by a transparent supply chain narrative.
– Consumer customisation opportunities are opened up through a new approach in manufacturing that is smaller, embraces new technologies and is closer to the market. With this closer consumer engagement, a sense of 'made by me' is imparted to clothing supporting greater longevity for garments within the system.

Production Risk Mitigation With manufacturing being closer to the company headquarters, a greater sense of control can be gleamed over the manufacture of products including the quality of the garments being made, the sustainability processes embraced and greater confidence over supply and demand.

– Resource constraints could be overcome by utilising localised supply and production which have been experienced recently through periods of conflict and the global pandemic. Furthermore, this would enable resource and manufacturing self-sufficiency contributing to a regenerative localised model of production and consumption.
– Furthermore, this will facilitate a more controlled level of social compliance with auditing practices executed with ease and business operating under UK governance and legislation. Gao et al. (2018) believe that the environmental sustainability of a supply chain could be enhanced due to such events as greener operations of developed country firms.

In accordance with the climate targets set out in The Paris Agreement and in response to the call to action set out by The United Nations to address the climate emergency, reshoring production can contribute in multiple ways towards achieving the Sustainable Development Goals. To work within the resource boundaries of the UK, low or zero water manufacturing solutions will need to be implemented

especially within colouration and dying of textiles (No. 6 – Clean Water and Sanitation). This approach will not only utilise far less water than current methods but also create less water waste and polluted water from production processes. Furthermore, the integration of advanced technology will aid in the development of clean manufacturing methods, utilising renewable power sources and creating less emissions (No. 13 – Climate Action). This relates closely with the use of industry infrastructure and boosting the UK's innovative textile and garment manufacturing globally (No. 9 – Industry innovation and infrastructure). With the key in-country motivations for reshoring, the development of the national economy in the creation of jobs and industry revenue begins to protect self-reliance and supply of necessary resources (No. 8 – Decent Work and Economic Growth). When considering the supply chain narrative in building product-consumer value through customisation, Responsible Production and Consumption (No. 12) becomes the focus. However, just as intended with the SDG's, these factors cannot work in isolation and rely heavily on the success of other areas of growth and development (No. 17 – Partnerships of the Goals).

3.1.1 Current UK Manufacture

As discussed earlier in the chapter, current practice does not align the UK with garment and textile production; however, there remains several established brands who have either re-shored their production in-country or who have built their business on the foundation of a Made in UK approach. Several examples of best practice can be highlighted within a UK context, where brands have already started to relocate some of their production closer to their business location. These brands currently work within the true sense of onshoring or backshoring, with further consideration needed to produce commercially at scale to embrace new-shoring or next-shoring approaches.

- Community Clothing owned by Patrick Grant adopts a Made in UK model, covering the full supply chain, established with a simple goal in mind; 'to sell quality affordable clothing and by doing so, sustain and create great jobs in the UK's textile making regions. Each product comes from one of their 28 partner factories (most of which are family owned) including spinners, weavers, knitter, dyers and finishers across Lancashire, the East Midlands, Scotland and South Wales. Furthermore, they position their manufacturing in some of the UK's most deprived areas, creating economic prosperity and jobs within the local area. As a company, they pride themselves on quality, sustainable products that are made to last a lifetime.
- Hiut Denim Co. have embraced their heritage, where for three decades they produced 35,000 pairs of jeans per week; however just like much of the production within the UK, this was relocated overseas in the 1980s, leaving 400 people unemployed. However, Hiut Denim Co. have re-shored their production back to Cardigan in Wales to where the knowhow and skill have remained. This is an

example of how the DNA of an industry has been retained within a community, despite the skilled workforce spanning generations of families.
- British luxury brand Burberry retain some manufacturing within the UK, especially with heritage products synonymous with the Burberry brand. For example, they weave gabardine fabric invented by Thomas Burberry in Keighley and their traditional trench coat products are made in Castleford, both within Yorkshire. This example links the British manufacturing heritage and iconic textile production with the UK as a manufacturing location.
- British apparel brand Finisterre made a commitment back in 2005 to position Marino wool as a key fibre component in their collections, due to its heritage properties and sustainable credentials. However, sourcing became an issue as there were only 28 Bowmont Marino sheep within the UK which could not supply the quantity of product needed. Working in close collaboration with the flock owner for nearly a decade and the future of the breed has been established with almost 300 Bowmont Marino sheep not residing in the UK, building a 100% British supply chain from scratch.

3.1.2 Feasibility of Reshoring Garment Manufacture

When considering the feasibility of reshoring textile and garment manufacturing to the UK, it is also to be acknowledged the geographical lack of resources available, thus leading through sustainability practices could begin to set the UK apart from alternative production regions. Access to land, natural resources such as water and manufacturing infrastructure is scarce, thus, alternative, responsible methods can begin to build a bottom-up approach in volume-led global manufacturing regions. Consequently, this approach will operate within global and environmental boundaries from necessity rather than subjective and voluntary action.

Further considerations within the value chain are also necessary when considering feasibility of reshoring garment manufacture including resource efficiency, infrastructure, and technology capabilities. Water usage for example is a key consideration, integral to the production of textiles and fashion products; however, within a UK context, the high cost of fresh water and wastewater processing will need to be addressed through the integration of low water technologies within the dying and processing phases. A critical argument opposing the implementation of UK manufacturing is the limited existing worker infrastructure and the comparative high cost of labour. A prevalent skills gap exists since the offshoring of production in the 1980s, with the aging workforce retiring and a lack of apprenticeships and training to replenish staff. The use of advanced robotic automation could aid in addressing this core challenge (as already evidenced in agriculture and automotive industries in the UK); however, unlike industries commercially adopting automation today, further considerations specific to the clothing industry around the handling of lightweight fabrics through robotics and accuracy of manufacture is needed.

Restrictions around geographical location present further challenges in the relocation of production. In comparison to manufacturing localities in Asia, the UK has

restrictions on space and available land which could be used for factory sites. Rethinking factory footprints will be integral, alongside the streamlining and simplification of the long manufacturing process currently utilised in global supply chains. For example, Stenter machines are critical to the core of textile production to dry and set materials but require space as a minimum of 60 meters. However, these challenges have been overcome in other industries, such as farming which has moved towards a vertical farming method to reduce space, while still performing at full capacity. By taking systems change approach, this could be challenged and ultimately removed as a process requirement, for example if wet textile processing was eliminated or replaced with other processing methodologies. Considering unused, non-traditional spaces within the UK may also provide answers, such as redundant retail space. With cleaner manufacturing from newer and more closely regulated processes, clothing manufacture can be bought into city centres that have large spaces and accessible transportation networks as well as closer access to the consumers. Furthermore, cleaner manufacturing will be paramount due to high energy costs and restrictions on industrial emissions. The textile industry is an energy intensive industry and new thinking will be imperative, the UK has an opportunity to lead through example to high volume manufacturing countries within Southeast Asia, where coal is still used as fuel within textiles. Additionally, positioning the consumer at the core of the drive towards sustainability can aid in fast tracking progress, with this approach previously adopted within the food industry, where ethical and sustainable supply chains remain an expectation.

3.2 Technology Driven Innovation

As detailed, the supply chain is a long, complex process and a knee-jerk reaction to relocation could be counterintuitive and potentially catastrophic for existing global supply chains. A phased, modular approach would facilitate staged change but ensure correct measures have been taken to not jeopardise supply while maximising the UK's potential to onshore production.

Adopting a small scale, yet high value approach to the development of ranges could maximise the potential of UK heritage and the craftmanship narrative within the supply chain. Referring to Community Clothing as an example, they embrace the slow manufacture of their products, with their unique selling point being around the supply of Made in UK products at a reasonable price and supplied in manageable quantities. Embedding this approach within the brand story goes beyond creating disposable clothing but develop value and emotional connection at a consumer level. Moreover, the brand examples already discussed create a connection between the product and the maker, with Hiut Denim Co. assigning each individually crafted product to a particular member of their work force, with the machinist signing the label for each piece they make. Additionally, UK brand Harris Tweed have emphasised their heritage narrative through collaboration with mass market brands such as Nike, Vans, Topman and Adidas.

To increase possibilities of UK manufacturing, the adoption of technology driven innovation is crucial to overcome some of the core challenges highlighted and discussed throughout this chapter. As framed within the context of the garment value chain, the following areas of advanced innovation could be explored:

Dyeing and Printing

- Super critical CO_2 dyeing – currently being utilised in Taiwan, Thailand and Vietnam, this process utilises no water resources and likewise, produces no polluted wastewater as with traditional dying processes. 50% less energy is used (due to the reduced need to heat water, dry fabrics, etc.) and 50% less chemistry (using pure pigments, reducing the need for a lot of the auxiliary chemicals needed in more traditional dyes). Additionally, the CO_2 used in the process is recycled and the factory footprint is greatly reduced. This technology would enable brands to ship greige knitted fabric to the UK in one scenario and dye smaller lots, closer to market and the consumer. Currently, this process is only being utilised in a commercial context with the colouration of polyester but has opportunities to be rolled out for other fibre types to impart performance to a fabric through the application of performance chemistry, replacing traditional wet processes.
- Dope dye (spun or solution) – while this is not a new technology it has been experiencing a resurgence since the focus on lower energy and lower water technologies have come under scrutiny. The process utilises 80% less water and consequently lower energy. Pigment (colour) is added at the polymer stage at the start of the process, rather than using water, energy and space intensive processing later on in the manufacturing stages. While increasing dope dye production within the UK at this stage may not be a solution, by purchasing pre-dyed, dope dyed polymer or yarn, later textile production steps (undertaken in the UK) can be much reduced as there is no subsequent need for fabric dyeing (i.e. backshoring).
- Zonal printing – applies colouration to fabric only where needed through high-speed digital printing (i.e. garment panel are first printed then constructed). In 2019, new digital printing technology emerged that printed fabric at up to 90 metres per minute, presenting great commercial opportunity for UK manufacturing. Furthermore, water and energy usage are significantly reduced. From a practical implementation perspective, this technology enables retailers or designers to send an order to a local print house, also known as a *fulfiller,* where designs are printed directly onto the fabric and garments produced in just a few minutes. The system eliminates the need for long lead times and helps retailers to minimise waste instead of having to make large orders months in advance, they can quickly and flexibly respond to demand.

Knit technologies: A design led approach to knitting technologies can considerably reduce the process from raw material to finished garment, thus making it an attractive opportunity for UK manufacturing. Yarn is knitted directly into a garment bypassing the need for complex lengthy cut, make and trim (CMT) processes utilising minimal stitching.

– Weft Knit seamless – again while this is not a new technology, onshoring the application of this technology to the UK would integrate traditional craft processes with advanced technology methods. Weft knitted seamless garments, traditionally focused to lingerie and sportwear, are knitted in tubular form and therefore can be designed to require very minimal CMT. This makes it a favourable technology for global regions where labour is expensive or in short supply (i.e. The UK). The expertise is held within the application of technology and design, which again makes it a very favourable approach for UK onshoring. Due to the reduction in processes, lead times can also be reduced.
– Warp knit seamless – This technology is less used across the industry due to the larger footprint machines, slow production speeds, reduction in production flexibility but does empower the role of the designer. Edges can be easily raw cut and elements of customisation can be incorporated. Although the machines themselves are large, it does cut out the need for many additional CMT processes, thus shortening the complexities within UK manufacturing.

Manufacture

– Polymer to product – Turning the linear production process on its head, direct polymer to product manufacture bypasses the many additional processes used in textile and garment manufacture such as fibre extrusion, yarn spinning, textile manufacture (knit or woven) and CMT into a garment. This has huge potential not only at a sustainability level (through a reduction in workforce, resources, time and space requirements) but also from a customisation point of view. Exploration to date, although mainly at the concept level, has taken place in garments, textiles and accessories (i.e. footwear/eyewear, etc.) in areas such as:

    • Additive manufacture /3D printing – a collaboration between Loughborough University and the Yeh Group created fully flexible 3D textile uppers for footwear in a vision to be able to 100% manufacture 3D printed footwear and apparel which is completely customisable to each individual customer. Commercial examples can be found already in fashion accessories, although moving into more flexible forms (i.e. fashion fabrics and textiles has limitations). Examples of existing commercial use includes brand such as The Sole Theory and Adidas Futurecraft. While Design ideas currently supersede technology and material readiness, it provides opportunities to 3D print products at the site of the machinery.
    • *Non-wovens/Spray-on clothing* – Fabrican Spray-on fabric creates an instant sprayable non-woven fabric directly onto the human body, thus bypassing the need for lengthy processing. Developed from sustainability concerns within the fashion industry, this new technology, showcased during the Paris Haute Couture Fashion Week (2022), embraces a circular approach, enabling total recyclability at end of use when it can be dissolved and resprayed into a new garment.

– Industry 4.0 – Many experts consider Industry 4.0 to be the production method of the future. The aim is to combine the latest digital technology with the automation possibilities of big data and new production methods. Smaller, decentral-

ised and highly automated production facilities right where the consumer is located. The goal is a whole network of new sites that use intelligent robot technology will exchange data with each other.

- Speed factories – the highly innovative concept of the Speed Factory is based on the idea of Industry 4.0 previously used by Adidas, but challenges in the process arose when labour costs were overlooked due to an increased staged approach that garment manufacture needed.
- *Robotics* – the adoption of automation remains slow within garment manufacture as compared to other industries as fluid, light weight fabric and stretch properties are difficult to work with effectively from a machinery perspective. While workers can adapt to a fabric's stretchiness or tendency to fold, machines may not properly move or handle fabric, causing them to make mistakes or damage raw materials. However, the development of Robotextil begins to address this, with this technology designed to pick up each fabric layer and set it down again safely and smoothly at the desired position for sewing and surging operations.

Performance finishes: Traditionally, garment performance finishes (such as water repellence, moisture management, stain resistance, etc.) are applied in the textile form during manufacture which requires additional wet processes on the fabric after the textile has been coloured. This adds time, and additional processes that have the associated water, energy, and chemical impact. To support the infrastructure of manufacturing with the UK, the factory footprint, and complexity of application needs to be reduced while upholding the performance that the garment requires.

– *Cold plasma treatment* – is used in various industries to impart a surface treatment and or a performance function onto a material. Initially adopted more broadly within electronics and high value/small part industries, it can perform various performance finishes with lower chemical use and more zonal application requiring a smaller factory footprint.

4 Conclusions

This chapter has primarily analysed the traditional methods and processes undertaken within the textile and garment value chain, highlighting challenges and areas for opportunity for both more established reshoring, or onshoring, but also more commercially framed new-shoring or next-shoring, manufacturing technologies to the UK. While the feasibility of relocating large scale garment manufacture has been challenged, this text approaches this from the perspective of identifying ways to make reshoring and new-shoring work to fulfil a current and contemporary industry need. As previously discussed, these debates go beyond the primary driver being sustainability or responsible practices, but within the practical implementation of

production methods and processes in a UK context, advanced technology is critical which often encompasses reduced resource and energy applications.

It is to be acknowledged, that a business-as-usual approach to relocating production will not be possible, with the UK needing to carve out its unique approach to manufacture while embracing advancements in technology to overcome geographical and social challenges. Feasibility will require bold action and cross industry collaboration to create leverage across the value chain, while additionally empowering consumers to co-design commercial possibilities from a participatory design perspective. Companies within critical operational positions in the UK industry need to draw on the textile heritage and historical positioning where possible, embracing previous knowledge and practice within the existing DNA of textile and garment production regions. Maximisation of a modular, gradual shift towards relocating production will futureproof supply chains and ensure a consistency in supply.

Governmental support will be crucial in the success of expanding the industry, with environmental and fiscal modelling needed to determine scalability and economic prosperity within degrowth parameters of the fashion industry. Primary funding will also be required to develop pilot and concept testing, enabling an elementary approach to support technology landscapes to evolve and grow. Obviously within the current period of financial instability and economic downturn within the UK, a financial reliant model is paramount to the success of initial activity.

Many of the proposed opportunities to embrace innovative, technological advancements adopt responsible manufacturing practices and will significantly reduce resource and energy use, emissions and waste within the supply chain. Additionally, the social implications of relocating operations to in-country locations are extensive, with the creation of secure jobs, upskilling and training opportunities and the further development of existing skilled worker communities. Furthermore, the consideration of locating some manufacturing to non-traditional spaces such as disused retail spaces could begin to integrate garment and textile production within the infrastructure of cities the length and breadth of the country. While reshoring, onshoring, new-shoring and next-shoring of production is not a quick-fix to many of the financial and sustainability issues currently facing the country, it does explore the medium to longer-term opportunities to reposition the UK as a global leader within textile and garment manufacture.

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Consumer Perspectives of Rental of Outdoor Clothing

Cecilia Mark-Herbert and Lovisa Byfors

Abstract Sustainability impact from the clothing industry, in every step of the life cycle is a global problem. This chapter investigates the customer perspective on renting clothes, more specifically clothes for outdoor activities. It assumes a need for a transition to take place where efficient use of resources is given priority. This transition in production and consumption is, in this case, studied in a case study of rental. Rental is associated with a number of challenges for the rental agent as well as the customer. The aim of the research project was to develop a better understanding of customer perspectives on renting outdoor clothing. A case study, Haglöfs in Stockholm, served as an empirical context. The conceptual framework, social practice theory offers three dimensions to explain consumer behavior: material, meaning and competence. Implications of this study may pave the way for developing a more customer focused rental business model in the industry.

Keywords Business model · Cost · Efficiency · Extending product life · Leasing · Practices · Textile · Sustainability transition

1 Introduction

The current global textile industry is associated with numerous sustainability challenges (Franco, 2017; Muthu, 2017) related to undesired environmental effects (Cousins et al., 2019; Islam & Islam, 2021), social problems (Akbar & Ahsan, 2021) and financial inequalities (Stigzelius & Mark-Herbert, 2009). The nature of the

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sustainability challenges can be described as global and interrelated (Boström & Micheletti, 2016; Zimon & Domingues, 2018). Ten percent of the world's carbon emissions is caused by human needs for clothing, which makes the textile industry the second most polluting industry in the world (The World Bank, 2019). The textile industry causes severe environmental impacts from the production of hazardous substances in garments, mass consumption, and large volumes of textile waste. About 80% of a garment's climate impact originates in the production phase (Mistra Future Fashion, 2019, 9) which points to needs for a transition, to minimize the needed production of textile.

1.1 Needs for a Transition in the Textile Industry

The transformation of the industry needs to take a triple bottom line approach (Elkington, 1999), acknowledging social, environmental, and economic dimensions of value creation with a vast number of stakeholder's needs in mind (Fischer & Pascucci, 2016; Kozlowski et al., 2012). The needed transformation is, in most research projects, seen from a production perspective in development of new production methods (Muthu, 2017), new materials (Huang et al., 2021), new design practices (Karell & Niniimäki, 2020; Pal, 2017), recycling practices (Juanga-Labayen et al., 2022), cost structures for production (Harper, 2022) and business models (Gardetti, 2019; Nyvall et al., 2023). These needs are motivated by severe environmental impact from the clothing industry in every step of the life cycle for garments, and especially so in the production. The high climate impact from the production in a textile value chain where textiles are only used for a limited time by the consumer generate massive volumes of textile waste (Jönsson et al., 2013; Juanga-Labayen et al., 2022; Mistra Future Fashion, 2019, 9), which means that both production and consumption needs to be considered as one system. The needed transformation is sometimes presented as a new ontology, a circular economy (**CE**) that closes the linear value chains to create systems were resources are used more efficiently (Chen et al., 2021).

A contemporary report by researchers at Ellen MacArthur Foundation (2022) stated that a circular economy is based on three principles: design to eliminate waste and pollution, keep products and materials in use, and regenerate natural systems. In this report, it is also argued that rental as a business model keeps products at their highest value and decouples economic development from resource consumption. Rental is one way to be able to keep products and materials in use, so that every garment hopefully has a longer active lifetime, with more usages (Gueye, 2021). Despite SDG 12, focusing on both production and consumption, much effort has been placed on finding sustainable alternatives for production. This chapter therefore focuses on consumer perspectives in consumption.

The transition in focus in this empirical case study pertains to offering consumers to rent the needed textile product instead of purchasing it. To investigate customer perspective on renting clothes, more specifically clothes for outdoor activities,

a research project was designed with the support of an outdoor cloths manufacturing company, Haglöfs, that has its own retail store in Stockholm. Their interest in consumer practices was key for the project. Before accounting for aims and outcomes of the empirical case, we want to provide a stage for understanding ambitions for circular economy in Sweden. This stage serves as a context for a presentation of the approach in terms of method and conceptual framework, followed by a presentation of the case study and the analysis and discussion of what it means for a transition in terms of social practice theory dimensions: materials, meanings, and competence.

1.2 Circular Economy for Resource Efficiency in Sweden

The global goals, the 17 SDGs, were agreed upon by 193 world leaders, to end extreme poverty, inequality, and climate change by 2030 (The Global Goals, 2022). Goal number 12 points to the importance of responsible consumption and production. Goal 12 aims for sustainable management and use of natural resources, responsible management of chemicals and waste, and promoting a universal understanding of sustainable lifestyles. Some things listed as sub-goals for SDG 12 relate to consumption formats, to buy second-hand, shop, eat and drink locally, and choose reusable products (The Global Goals, 2022).

In support of the SDGs, a Swedish policy was presented as a new proposal for climate impact connected to consumption (RK, 2022a, b, c). In April 2022, it was proclaimed that the Government Office of Sweden (RK, 2022a, b, c) has received a proposal for new climate targets on consumption and exports from the Environmental Objectives Committee's partial report. The Committee proposes among other topics, that the climate policy framework should be supplemented with objectives on climate impact from consumption and the climate benefits from exports. The proposal sets targets for climate impact of consumption, a long-term goal of reaching a negative net release by 2045 (RK, 2022a, b, c). The ambition is that Sweden will take responsibility for consumption-related emissions globally and will be the first country in the world to have targets regarding consumption (Klimatkommunerna, 2022).

Political goals may serve as a first step, but the circular economy is also dependent on changes in attitude among consumers at large, and changes in production and consumption systems reflected in institutional economic systems (Rise, 2022c). This assumes challenging the traditional product dominant logic to open for a service dominant logic that has consumer needs, services, in focus (Brent et al., 2016). These thoughts are not new. Already in 2012, Bergman and Klefsjö, among others, argued for the needs to redefine value creation and quality, taking a consumer perspective.

According to The Swedish Environmental Protection Agency's (2021, 8) report on sustainable textiles from 2020, almost nine out of ten people in Sweden from 17 years old, would consider renting or borrowing clothes. About 28% of the respondents in this study could consider renting or borrowing clothing if they knew

it would make an environmental difference. The Mistra Future Fashion report (2019, 17) describes a discrepancy between attitude and action when looking at customer behavior in textile consumption. Most users in their research express an intent to consume more sustainably, but this attitude is not reflected in their actual behavior.

Looking at the statics from The Swedish Environmental Protection Agency (2021, 8) which shows that there is a will to change consumption behavior among consumers at large if it comes with environmental benefits, renting could be one way to participate in working towards responsible consumption and production and the global goal number 12 (The Global Goals, 2022). As argued in The Mistra Future Fashion (2019, 17) report, where there is a discrepancy between attitude and action, there is a need for research on the customer perspective and the customer practices to learn more about how the rental model can be developed.

1.3 Research Focus and Aim

This case study investigates the consumer perspective on renting clothes, more specifically clothes for outdoor activities. The aim of the research project was to explain consumer perspectives on renting outdoor clothing. Implications of this study may pave the way for developing a more consumer focused rental business model in the industry.

Focus was placed on consumer attitudes of consumers that visited the Haglöfs retail store in Stockholm. They are not to be regarded as a randomized sample which means that the results cannot be generalized. A consumer study in Sweden in a Haglöfs retail store in other geographical locations, or at a different time of the year, may also provide a different consumer profile. The results are therefore seen as a case study of consumers at a particular place and time.

With an ambition to understand consumer's practices, rental of clothes at a particular time, social practice theory (**SPT**) served these needs well. Questions were focused on the three elements of practice: materials, meanings, and competence with an open mind of additional elements that the SPT may not cover. The arguments for using SPT are presented in detail in the next section; they relate to ambitions to get an understanding that is bound to a context (practical settings of rental as an alternative to a purchase) as well as consumers' understandings of motives for doing things the way they do (practices).

2 Approach

In this project the approach, choices related to a conceptual framework, collection and analysis of data were harmonized. The project focused on people, consumers, in a social setting seen as a case study with a fixed design; the project relied on both quantitative and qualitative data. Given an aim is to understand consumer practices,

a survey was developed that explains the three dimensions of practice theory (further explained in Sect. 2.5).

2.1 Research Design

In this project, the selected unit of analysis, consumers visiting an Haglöfs' outdoor retail store in Stockholm from end of April until middle of May, was made based on three criteria. The first criterion relates to Haglöfs' long-standing history of working diligently with sustainability issues (Erdnüß, 2016). Second, their customers are interested in outdoor activities which is assumed to be associated with awareness of consumption aspects of sustainability (ibid.). The third criterion has to do with corporate support for conducting the study.

The context for the empirical data collection is described in terms of physical and social dimensions (Franklin & Blyton, 2011, 54). This case study is performed in a physical Haglöfs store in Stockholm and focuses on the customers in the store at the time. The social dimension is hard to capture in words. Photos were therefore taken with ambitions to capture the social ambiance, the context in which consumers, visiting the Haglöfs store, were offered to participate in the study (Byfors, 2022). The case study was chosen to explore possibilities and potentials with ambitions to contribute to the development of a service dominant logic business model based on rental practices.

Data collection was carried out in two steps. The first step, a traditional literature review, investigation in Statistics Sweden background data and review of internal corporate documents, gave an empirical platform for conducting the second step, a consumer survey. The survey was performed in a physical Haglöfs store in Stockholm from end of April until middle of May. The goal was to reach 100 customers to develop an understanding of their views on renting clothes for the outdoor activities such as skiing, hiking, camping, biking, and mountaineering. To inspire customers in the store to participate in the survey, a poll was made among respondent with a backpack from Haglöfs as a winners' reward. The customers were not deliberately targeted or forced to do the survey; they were offered a chance to contribute, and they made their own choice to participate by scanning the QR code on the signs in the store. The signs in the store can be seen in Appendix A.

The survey (Appendix B) has a high level of structurization and a mix between a high and a low level of structuring, meaning the survey contains questions with fixed response options and open questions (Patel & Davidson, 2011, 76). Questions in the survey were developed with consideration of the theoretical perspective (Social Practice Theory, further presented in Sect. 2.5) and methodological recommendations from Patel and Davidson (2011, 78), for example, to avoid long sentences and leading questions, prerequisites, negations, etc. The questionnaire was developed with consideration of respondents' assumed outdoor interests and with explanations of technical terms to make it easy to understand the questions (ibid., 79).

2.2 *Quality Assurance of the Research Process*

Quality assurance of a research project is visible in the many choices made, reflection along the way and in post project learning. Our efforts in this approach are further described in Table 1 where we explain how reliability and validity has been obtained.

In addition to the validity and reliability dimensions in quality assurance, close attention has been given to ethical aspects relating to GDPR following university guidelines (Swedish Research Council, 2022) and social science research conduct in general (Patel & Davidson, 2011). Informed consent was obtained in a clear presentation of the project, how the data was going to be used and a possibility to withdraw for a respondent at any time. Confidentiality principles and the option to be anonymous unless a respondent wanted to be part of the back-pack lottery, served as principles for the data collection.

Table 1 Quality assurance in a case study

Yin (2009) classification	Guba and Lincoln (1994) classification	Meaning	Taken steps
Internal validity	Credibility	Seeks to establish causal relationship	A logical analysis process—Making use of data in a transparent process that is well connected to the conceptual framework
External validity	Transferability	Defines to what extend study's findings can be generalized	Theory is used for the analysis. The study consists of one case. It is up to the reader to transfer the understandings to a different context
Reliability	Dependability	Demonstrates that the operations of the study can be repeated	Used theories are stated, matching between research features and research design are accounted for
	Confirmability	Ensuring that personal values and theoretical inclinations of the researcher do not influence the research and findings	Usage of publicly available documentation as a primary source of data ensures independence of the researcher from the case. Choice of theories for the analyses based on an extensive literature review
Construct validity		Identifies correct measures for the concepts of research	Several sources of evidence are used, these sources are documented

Based on Bryman (2008, 19, 376–379), Guba and Lincoln (1994) and Yin (2009, 40–45)

2.3 A Conceptual Framework

Value creation refers to meeting consumer needs of outdoor clothing in this project. Assuming the consumer does not have the clothing or can borrow it from a friend, the options are to buy a product or rent it, assuming that a rental-service is offered. The conceptual framework for this project therefore reflects the understandings of the current norm as buying and the added option of renting. The process of adding services to a product offer, from a corporate perspective, is referred to as "servitization" of a product service system (Baines et al., 2007; Baines & Lightfoot, 2014). In this project, the system is studied from a practical perspective focusing on practices that enable the rental alternative. A presentation of the concept of a service system is further presented below, followed by the consumer behavior model that focuses on practices, Social Practice Theory (**SPT**).

2.4 Servicification in a Product Service-System

"Servitization" captures the notion of adding services to non-service sectors of an economy of an industry. Trim (2021) describes in the article a three-sector model used to explain how industrial economies are structured, the primary sector with raw material extraction, the secondary sector with product manufacturing, and the tertiary sector with services. The primary and the secondary sector can servicify their role in the supply chain by delivering their goods to the next sectors themselves, instead of outsourcing to a tertiary sector business. Servitization does not have to be limited to extraction or manufacturing and this is now seen in the fashion industry, where services are also added to the products (Baines et al., 2007; Baines & Lightfoot, 2014). Product servitization can generate additional revenue in ways such as rental and resale models which generate multiple sales for a single product. Services can also help increase the lifetime of a product, for example by in-store repairs and brands can offer services such as taking responsibility for the product's end-of-life stage, when it is no longer possible to resell or repair the product. Trim (2021) argues that servitization plays a very important role in fashion's sustainability revolution.

Product Service-System (**PSS**), on the other hand, is a special case of servitization. A **PSS** can be seen as a market proposition that extends the traditional functionality of a product by additional services (Boehm & Thomas, 2013). This is more a sale of the *use* than the sale of the product. There is no transfer of ownership. The use is what the customer pays for, and the customer also benefits from not having to deal with the risks, responsibilities, and costs that follow with ownership of a product. The expectation is that PSS will have a lower environmental impact than a more traditional transaction (Baines et al., 2007; Cook et al., 2006; Tukker & Tischner, 2006) where the consumer owns the product after having bought it.

Table 2 Context-bound factors that may limit the use of product service-system development

Factors of importance	Industrial context	Source
Logistics/transport	Construction, engineering, electrically powered tools	Martin et al. (2021)
Variety in product offer	Clothing, fashion	Armstrong et al. (2015)
Hygiene, washing	Clothing, fashion	Mont (2004)
Consumer travels	Any	Gofetti et al. (2022)
Frequency in use	Any	Blüher et al. (2020) and Tukker (2004)
Educational efforts	Fashion industry	Pereira et al. (2021) and Shrivastava et al. (2021)

Studies of PSS in various industrial sectors suggest that there are several factors that needs to be included in an analysis of sustainability challenges (Table 2).

Table 2 suggests that some factors are directly related to the product-service itself and other factors are related to the context in which the system resides. Given the notion of a system (PSS), we need to set boundaries of this system to be able to compare alternatives. Since this project was developed to explain conditions for outdoor rental from a consumer perspective, the boundaries are decided by what the consumers spontaneously relate to as part of the rental offer.

2.5 Social Practice Theory

Social Practice Theory (**SPT**) offers a conceptual model for consumer behavior. It focuses on what consumers do in terms of *practices* in purchasing, use and disposal of products rather than focusing on consumer attitudes to explain behavior. SPT is an approach that combines the components in context bound daily routines to understand actions of human beings (Ajzen, 1991), hence, consumers' actions instead of the attitudes are identified (Warde, 2005). It is further proposed that a conceptualization of consumers as the active practitioners rather than the users (Pantzar & Shove, 2005). These practices are more than the actual human behavior; they are actions taken bound to context dependent variables such as culture, physical conditions, and capability to see the action as part of a system (ibid.). They are usually routine activities of human beings such as eating and doing daily habitual behaviors.

The basic components and the understandings of the role of SPT was developed by Warde (2005) and Reckwitz (2002). According to Pantzar and Shove (2005), SPT explains human behavior, based on practical conditions for behaviors to take place. The model, developed by Watson et al. (2012), is presented in Fig. 1. It identifies the major elements in social practices of consumption, in terms of materials, meanings, and competence. They are not isolated but interconnected and needs to be understood in light of each other (Watson et al., 2012).

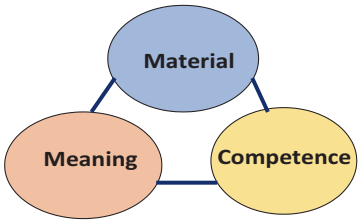


Fig. 1 Components of Social Practice Theory to explain behavior. (Watson et al., 2012:14 with modifications)

The components in the conceptual model for social practices in Fig. 1 are further explained below. *Materials* include the actual physical objects that are tangible, for example, human bodies, tools, infrastructure, and technologies, and they are usually directly related to human beings' daily lives (Pantzar & Shove, 2005). *Meanings* refer to the beliefs and understandings which are socially shared and connected with respect to the materials, different associations and culture may have different senses of what meanings are appropriate (Watson et al., 2012). *Competences* encompass techniques and skills that are required to perform a practice, thus, the way to recognize and respond to certain behavior (Pantzar & Shove, 2005). Practices are developed from continuous connections and linkages of its components, and the change of the components leads to change of the practice (ibid.). People tend to continue engaging in and carrying on the practice when they gain positive experiences by performing the practice (ibid.).

SPT focuses on the practices, what is done in a particular context. That has implications for data collection as well as the interpretation of the results. Contextual understandings are vital to understand the conditions for practices to evolve and become established.

3 Results

A presentation of the project is made in light of an empirical historical background (Sect. 3.1) that provides a stage for an account for the consumer survey investigation (Sects. 3.2, 3.3, 3.4 and 3.5) conducted in a Swedish outdoor retail store. The presentation of the empirical case follows the elements in the SPT model (materials, meanings, and competencies).

3.1 Empirical Background

In Isabelle McAllister's book "Skavank" [Flawed] (2021, 16ff), she tells the history of consumption behavior and how we ended up in today's consumption pattern. She describes how the industrialism made mass consumption possible. Important landmarks in a Swedish context since the 1940s are illustrated in Fig. 2.

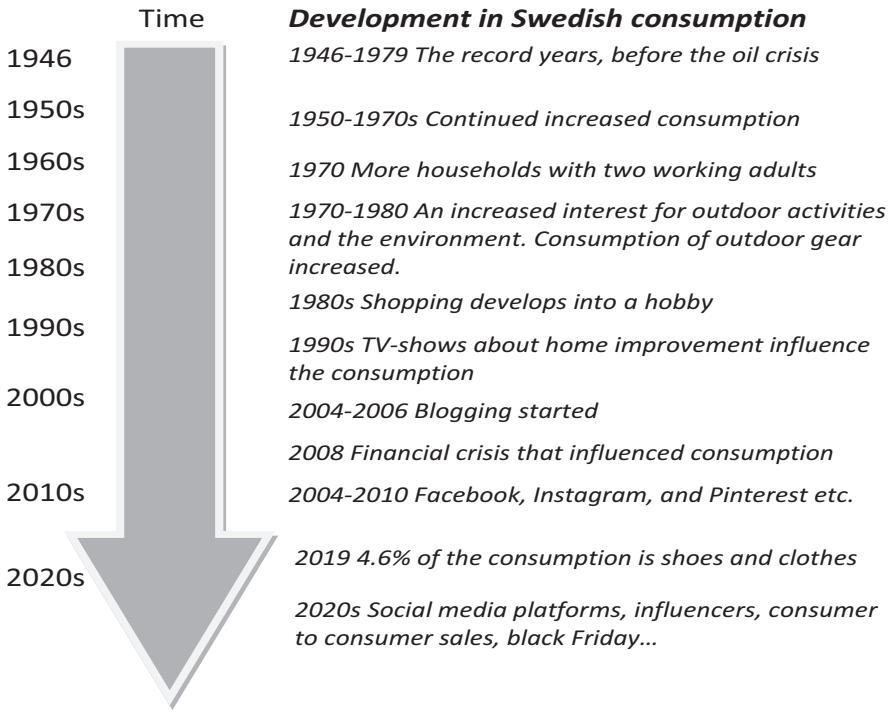


Fig. 2 A timeline of important events and landmarks over the years in the history of consumption behavior in Sweden since the 1940s based on McAllister (2021, 16ff), and supported by facts from Statistics Sweden (2020)

Figure 2 shows a timeline of important events at different times that influence Swedish consumption behavior and cultural norms. Isabella McAllister (2021, p. 16ff) describes how the economy improved after the second world war for the Swedish people. The time between 1946 and 1970 is sometimes called "the record years" when industries were prospering and consumption was thriving, except for the time for the oil crisis in the late 1970s.

In the period 1950–1970, salaries average household income raised, foreign trade increased, and new labor came to work in Sweden. During the 1960s, parental leave for working women was established along with the 5-day work week. More of both money and time for households lead to increased consumption (Statistics Sweden, 2020). Between the years 1950 and 1975, the Swedish people's purchasing power doubled. During the 1970s, more households than ever had two working adults, which led to more money but less time at a household level. This led to people buying more processed products, for example, by buying baked bread instead of flour, and fashion clothes instead of fabric to sew your own clothes (McAllister, 2021, 16ff).

During the 1980s, shopping became a hobby (McAllister, 2021, 16ff). This is in part explained by an increase in imported products (Statistics Sweden, 2020), lower

prices on fast moving consumer goods, which is explained by increased international competition. During the 1990s, tv shows about renovating your home became popular which influenced consumer behavior towards making home improvements. The next major trend is related to blogging, that started in 2004–2006. Lifestyle and fashion perspectives from influencers had major impact on consumption through tech platforms such as Facebook, Pinterest, and Instagram was developed in less than a decade, 2004 and 2010 (McAllister, 2021, 16ff).

Market development is, to a large extent, influenced by consumer trends and cultural norms. This is especially the case for the textile industry, which is one of the world's largest industries. It is considered to be the first industry in a process for a country to become industrialized (Johansson & Nilsson, 2016, 14–19). One of the reasons for the industry to prosper in an industrialization process is that it does not require big investments at start. A small-scale production would require sewing machines and materials, but no requirement for formally trained staff (ibid.). The fragmented industry and global world markets emphasize the importance of marketing and branding.

Resent consumption statistics reveal that the Swedish consumers buy thirteen kilograms of textiles per person and throw away eight kilograms per person on an *annual basis* (Johansson & Nilsson, 2016, 23–25). In other words, half of the amount of purchased textiles are thrown out—every year. In the five-step waste hierarchy (Fig. 3), Swedish consumers skip many alternative steps when they throw away (deposit) their clothes.

Consumers of textiles, and in this case the Swedish consumers, should in the five-step waste hierarchy on the first hand minimize their consumption, by buying less textiles (Fig. 3). They could also reuse the clothes they already have (in their wardrobe or with circular business models as secondhand or rent for example), recycle the textiles when there is less of a need, or incinerate (to create energy) and as a last possible option deposit the clothes.

Consumption Statistics from 2019 (Statistics Sweden, 2020) reveal that clothes and shoes represent 4.6% of the average Swedish household spendings. Consumption statistics reflect how people live their lives, and consumption statics over time tells us about the development of politics, economy, as well as political development (Statistics Sweden, 2020). Recent development, in the past decades also points to the importance of social media platforms that influence consumer behavior giving input about "outfit of the day," hauls, and unboxing, to show your followers what you purchased. Companies work with influencers for marketing. Black Friday hits records year after year, and a new type of tv-shop from China has arrived, where you can follow a live shopping with an influencer promoting products (McAllister, 2021, 20–21).

Representatives of the organization, Cirkulära Sverige (2022) describe the problem of the mass consumption of clothing that is sporadically used, and the solution to be renting clothing and other products connected to outdoor activities such as skiing, hiking, trail running, and other related activities. This solution gives access to products without the customer owning them, and companies can make more money on every product compared to if they would sell each product one time only.

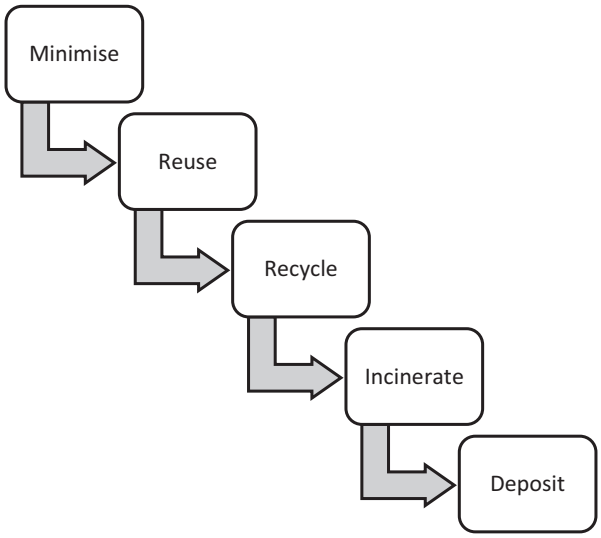


Fig. 3 The five-step waste hierarchy. (Johansson & Nilsson, 2016, 25, with modifications)

By companies offering their customers to rent high-quality products, the products live longer and can be used by many customers for a longer period. The customer does not need to take care of the products they use (Cirkulära Sverige, 2022).

3.2 Result of the Case Study

In this project, 101 customers in the store answered the survey. Of these, 50% of the respondents were women, 48% were men, and the rest (2%) identified as nonbinary. The participants in the survey were aged 18–79 years old. Each respondent may practice several different outdoor activities and could therefore report several kinds of activities. Among the respondents the most common activities were hiking and skiing (Fig. 4).

Among the respondents the most common activities were hiking (85.1%) and skiing (70.3%). The results show that 37.6% of the participants of the study are biking, 35.6% are camping, and 13.9% are practicing mountaineering. Other activities added by the respondents to the survey were running, collecting berries and mushrooms in the forest, fishing, judo, sailing, and boxing, each resulting in about 1% being practiced by the respondents.

Figure 4 also illustrates how experienced the respondents see themselves in each activity, with beginners in the bottom, average in the middle, and experienced in the top. Other activities added by the respondents in the survey are not specified in their experience of the activity in this figure.

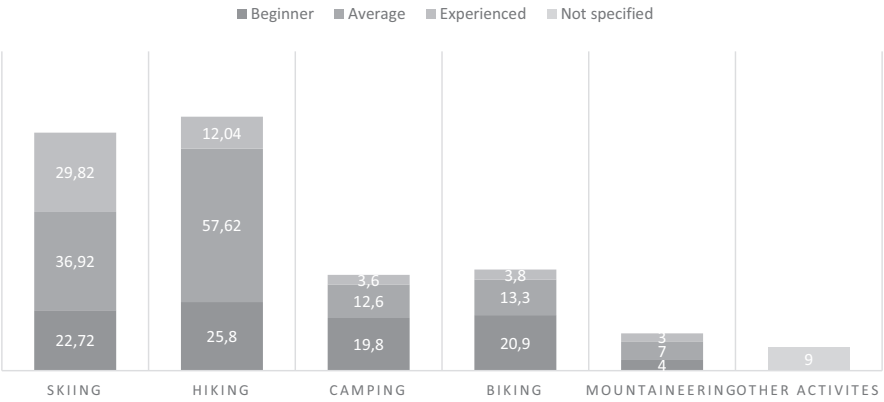


Fig. 4 Outdoor activities and experience among the respondents

3.3 Social Practice Theory – Materials

The material dimension stands for the importance of the physical surroundings, both objects and infrastructure, and our own bodies (Klitkou et al., 2022, 604–605; Shove et al., 2012, 14). The result connected to this dimension regards accessibility, the functionality of clothing, practical processes of renting, and quality for the customer (Table 3). Questions (all questions related to materials can be found in Appendix C) relating to materials focused on kind of outdoor activities, clothing needs, quality functions, payment methods and if rental is an overall option.

The result connected to this dimension regards accessibility, the functionality of clothing, practical processes of renting, and quality for the customer. It is understood from the result connected to the material dimension that respondents saying they are experienced in their outdoor activity are more likely to use their clothing more over the year, a couple of weeks every year, or even in their daily life. *Frequency in use*, a difference between experienced skiers and hikers in terms of how often their outdoor clothing is being used by themselves was also clear. Here, the trend of experienced hikers using their outdoor clothing throughout the year is bigger, and none of the experienced hikers use their outdoor clothing only once a year. One reason for this could be the active outdoor lifestyle this group has chosen, and the easier access to go on a hike compared to going skiing.

Experience of outdoor activities matter. The result shows that beginners of skiing and average skiers have more positive feelings on renting their outdoor clothing. A similar pattern was seen in different levels of expertise from hikers, campers, bikers, and mountaineers. This is likely to depend on the lifestyles and that people more experienced in their outdoor activities also use their clothing more, and thereby benefit from owning their clothing due to both economic reasons and accessibility, in other words, the logistics around their clothing for their outdoor lifestyle. The results also point out that people being more experienced in their outdoor activity is more likely to own their outdoor clothing when looking at the result of feelings

Table 3 Comments from respondents in the survey connected to materials, when asked if they wanted to add something the survey did not cover. The original comments can be seen in the survey result in Appendix C

Comments on the benefits of renting	General positive comments	Neutral or skeptical comments
It should be more accessible to rent clothes if we are to protect our nature. Good initiative	Perfect concept in stores in resorts near nature adventures	Have never tried, and did not know it was possible
Very exciting! Hoping for this service. This will also make material sports more accessible for others looking from a social perspective	Good to try in a physical store	I think it can be hard to get people to rent clothes, maybe possible if it is for a week or a specific adventure. Maybe if the clothes were rented for a whole ski season and that you then got the latest products on the market. The price must be good
	Could make it easier for the beginner	
Haglöfs is a premium product. This would be a reason for me to rent, for the good function	Possibility to try the product and rent in a physical store would be great! But I chose option to order online as there are not that many physical Haglöf stores near me	The price, if it feels to be worth it to rent more than to buy. Also questions around insurance
Good idea for technical clothing which are expensive, where you need many different kinds of sets and combinations for different kind of weather, activity, and length. Good for environmental and sustainability reasons	I really think renting outdoor clothes is the right in time. I don't know if this already exists, but if it does, more marketing about renting would be good	I see renting as a temporary complement, or a more qualified trying before buying

towards buying and that beginners have a less positive attitude towards buying their outdoor clothing than more experienced people in all represented activities in this section. It is also understood from the result that beginners especially in camping and biking are more positive about buying their own outdoor clothing than beginners in skiing and hiking.

Comments in Table 3 represent answers to an open-ended question about wiliness to rent. These comments were focused on benefits of the rental model, general positive comments, and more neutral or skeptical comments. Prahalad and Ramaswamy (2004, 7) argue in their article value will be created by both the firm and the consumer, and that high-quality interactions enable an individual customer to co-create unique experiences that will unlock new resources of competitive advantage. Taking these words in relation to the material dimension and the possibility to meet the needs of different customers in the rental service, the rental model must fit the lifestyle of the customer. The result shows the most wanted rental service model is to be able to try on and rent in a physical store, and to pay per product: 58% wanted to try on and rent in a physical store and 87% wanted to pay per product.

The material dimension (of SPT) points to the importance of the physical surroundings, both objects and infrastructure (Klitkou et al., 2022, 604–605; Shove et al., 2012, 14). Looking at the *expected quality* of rented clothing, 70% said they just expect the same level of function. A smaller group (22%) would like the rented outdoor clothing to look brand new, and the remaining 8% value the products being used many times no matter the look of them as long as they do not limit their planned activity. Survey respondents also provided comments on benefits towards quality and function of the rented clothing, for example, the following: "Good idea for technical clothing which is expensive, where you need many kinds of sets and combinations for a different kind of weather, activity, and length. Good for environmental and sustainability reasons," and "Haglöfs is a premium product. This would be a reason for me to rent, for the good function."

A material aspect of rental relates to letting consumers try out the clothing through renting would give them a chance of pre-evaluation of a planned purchase. Weetman (2022) argues one solution to stop the current system of clothing consumption is more durable products, and another solution to be products used by more than one person, for example by renting models. Twice as many uses per garment life cycle eliminated almost 50% of the impact, regardless of the impact categories climate impact, energy use, and water scarcity impact (Mistra Future Fashion, 2019, 13, 19). Again, letting the customers try the durability through renting, and making sure they buy the most suitable clothing for their needs could increase the product's lifetime.

A rental option may also strengthen relationship marketing ties between a consumer and a sales agent. It would allow for the pre-assessment of the product as well as valuable dialogues. Added value in terms of services places a focus on the use of products and needs. In an article by Trim (2021) sericitization is described as turning something into a service of adding a service to it. By doing this, more revenue streams can be created for the company and more value can be created for the consumers. Traditionally, sericitization involves adding services to non-service sectors of an economy of an industry. Ross Weetman (2022) suggests changing the current system to make the produced clothing being used more towards its real potential if customers make sure their purchases always meet their needs in the first place.

A benefit for the outdoor brands working with the rental model in combination with a linear business model is that it could be an interesting possibility to measure what products are being appreciated after the first trials. The current brand evaluation is only made based on sales statistics from which assumptions are made for upcoming production based on what was easier or harder to sell. These numbers do not reveal usefulness from a consumer perspective, what is being used, or put on a shelf, given away, or thrown away in any of the steps of the five-step waste hierarchy (Johansson & Nilsson, 2016, 25). With the rental model in combination with the linear business model, outdoor brands could produce clothing more tailored to what is actually being used by the customers. This is beneficial for both the company in economic terms, the environment with production hopefully in a better match with the actual future use and a smaller risk of overproduction, and the individual customer making the most of the outdoor clothing they choose to buy. On the other

hand, letting people try out new outdoor clothing could also inspire the individual to buy new clothing, and create a new desire they did not have before the rental. This perspective is developed further in the meanings section of this chapter (Sect. 3.4).

3.4 Social Practice Theory – Meanings

In SPT, the meaning dimension represent the element that guides the practice (Klitkou et al., 2022, 604–605). Meanings are symbols, aspirations, and ideas attached to behaviors and materials (Shove et al., 2012, 14) shown in Figs. 5 and 6. Questions (all questions related to meanings can be found in Appendix C) relating to meanings focused on: feelings towards renting or buying outdoor clothing, how one would treat the clothing, expectation of quality, and how one would feel to share the idea of renting outdoor clothing with friends.

Figure 5 shows that female respondents have a more positive attitude towards the renting model for outdoor clothing, either for themselves or for someone else compared to male respondents. The result also showed that 100 % of the nonbinary respondents are very interested in the concept for themselves or someone else but it is also worth considering reading this result that only 1% of the respondents represent this group. The attitude towards rental among the respondents is further illustrated in Fig. 6.

Figure 6 illustrates that the younger age groups and the age group 46–55 are more likely to have a positive feeling about renting outdoor clothing. Combining the results from Figs. 5 and 6, we understand that the group of women in the age group 26–35 have the most positive attitude towards renting outdoor clothing.

Another question strongly connected to the meaning dimension is the question of if the respondents would tell their friends about their rented outdoor clothing. Some 57.4% of the respondents would feel very proud to tell their friends about the rented clothing and hope to have inspired their friends to do the same next time going on an outdoor adventure, 41.6% of the respondents would tell their friends if the friends asked, and 1% would not like their friends to know about the rental. When analyzing this question in combination with gender, we can see the same pattern as with the question of feelings on renting outdoor clothing (Fig. 7).

Figure 7 shows that women are more likely to feel proud to tell their friends about their rented outdoor clothing and wish to inspire their friends to do the same. This question does not necessarily tell if men would be less proud of their rental clothing and could also be a result that shows differences in how men and women talk about clothing with their friends. This question is not researched in this study. However, the bigger part of the respondents in this study want to spread the word about a consumption choice they were proud of and would also like their actions to be spread and go on with other people around them. This is shown in a comment in Table 4, where a respondent rents out their things through the app “Hygglo,” where people can rent things from a private person nearby. The respondent is proud to

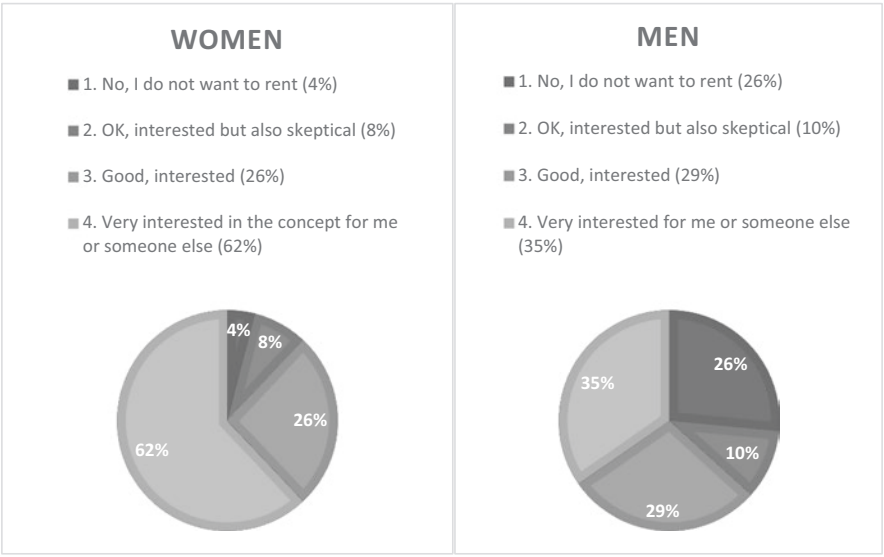


Fig. 5 Result for the question "What feelings do you have regarding renting outdoor clothes?" in relation to gender. Grades for feelings towards renting: 1 – No, I do not want to rent, 2 – OK, interested but also skeptical, 3 – Good, interested, 4 – Very interested in the concept for me or someone else

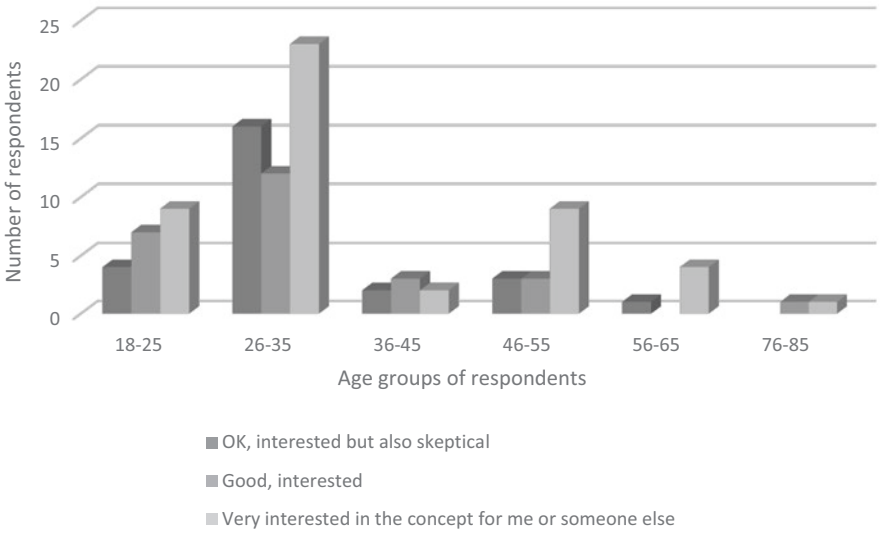


Fig. 6 Result for the question "What feelings do you have regarding renting outdoor clothes?" in relation to age. Grades for feelings towards renting: 1 – No, I do not want to rent, 2 – OK, interested but also skeptical, 3 – Good, interested, 4 – Very interested in the concept for me or someone else

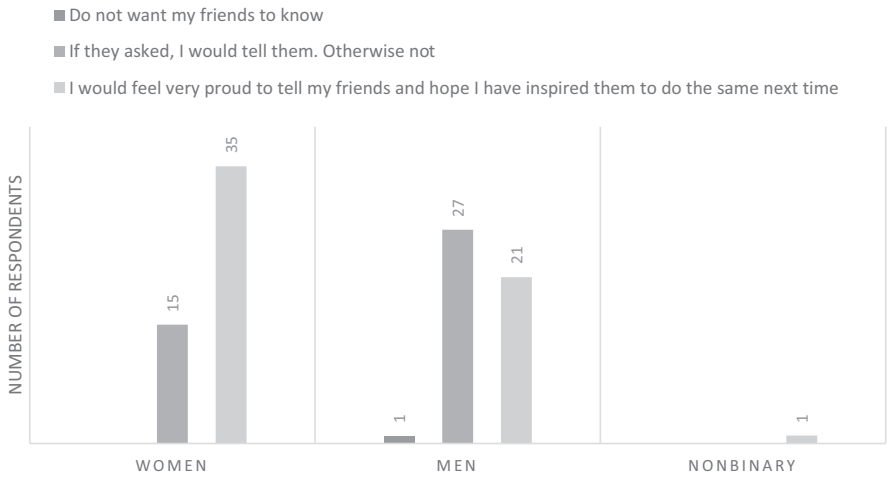


Fig. 7 Result from the question "If you rent outdoor clothes, how would you feel telling your friends about it?" in relation to gender

Table 4 Comments from respondents in the survey connected to meanings, when asked if they wanted to add something the survey did not cover

Comments from respondents
I really think renting outdoor clothes is the right in time. I don't know if this already exists, but if it does, more marketing about renting would be good
I see renting as a temporary complement, or a more qualified try before buying
I rent out my things through Hygglo and I am happy to see my things being used
Good idea but will not be used by me unless it is something really special, I almost never use

share their way of making the most of products already produced and wish to spread the word by writing this comment in the survey.

Added comments in the survey connected to the meaning dimension are related to that rented outdoor clothing is the right in time, that renting could work as a complement to being able to try your clothes before buying them, and that the model only works if it is for special trips or adventures. The last comment seen in Table 4, relates to how often the respondents wear their clothing and only sees the value of renting outdoor clothing if it is for some special adventure.

Consumer use of the rented cloths, practice, is crucial in a rental system. When it comes to the treatment of rented clothes, 51.5% of the respondents state that they would handle rented clothes with the same care as their own, 41.6% with even more care than their own, and 6.9% would handle rented clothes with less care than their own clothing. This question is connected to the respondent's treatment of their own outdoor clothing which is not the focus in this study. The result does not tell anything about the actual treatment (practice), but it does tell something about how the

respondents value clothing that belongs to themselves and clothing which are shared with others.

As presented in the materials section, the question "Would you expect the same level of quality on rented outdoor clothing as bought outdoor clothing?" showed that 70% say they do not expect the same quality, but the same level of function, and 22% expect the clothes to look brand new. The rest, 8% of the participants do not expect the same quality at all and value the things being used by many customers to get the most out of the produced garments. This question is highly connected to the meanings dimension as well because it shows what the respondents value. Of the respondents, 22% express expectation of rented clothing is that the garments should look brand new, which likely is not the case if the clothing has been used a couple of times before themselves. One reason for this could be that the motive of the rental is not environmental, but rather to be a solution to be able to wear the latest outdoor clothing on the market.

A study in Finland by Armstrong et al. (2015, 30–31) showed among other things a focus on the environmental benefits of various **PSS** scenarios among the focus group in the study, although no questions around environmental issues or sustainability were raised by the researchers. The environmental benefits of the presented scenarios in this study made **PSS** concepts attractive. This could be an explanation of the result of this case study of Haglöfs' customers; 57.4% of the respondents would feel very proud to tell their friends about the rented clothing and hope to inspire their friends to do the same next time going on an outdoor adventure. The environmental benefit of the consumption choice is given and predicted by the respondents.

On the other hand, the environmental motive to rent outdoor clothing is not shown in all results from all respondents. In the material-focused question, on what quality the respondents expect of their rented outdoor clothing, 8% said they value the products being used many times no matter the look of them as long as they do not limit their planned activity, and 22% answered they want the rented clothes to look brand new. Armstrong et al. (2015, 38–29) concluded in their work for instance the need to meet customers' need for newness and change, while also disconnecting material consumption from need satisfaction. It is also argued clothing in a PSS might be an opportunity for the industry to offer product quality, durability, and extended use time, and could this way increase overall satisfaction (Armstrong et al., 2015, 39).

Ross (Weetman, 2022), a specialist in Performance Sportswear Design and Sustainability, argues the performance difference of new outdoor clothing is microscopic, but the industry is designed to consume more. There is a risk that the rental model is contributing to this path. This logic could also be connected to the theory by Tversky and Kahneman (1974, 1984, 1989) where the acceptability of an option is said to depend on whether a negative outcome is evaluated as a cost or as an uncompensated loss.

3.5 Social Practice Theory – Competences

The competence dimension (Fig. 8) involves skills, know-how, and techniques (Shove et al., 2012, 14). Skills are the routine embodied skills, such as movements but also research competence for looking online for example (Klitkou et al., 2022, 604–605). Questions (all questions related to the competence dimension can be found in Appendix C) relating to competences focused on considered knowledge and accessible information.

The respondents are confident of their understandings of making an educated choice for an outdoor adventure. Some 67% of the respondents report fairly good or good enough knowledge. When asking the respondents if information about more sustainable choices for outdoor clothing is easily accessed 64% say it is mostly quite easily accessible or higher (Fig. 9). However, there is also a need of increased

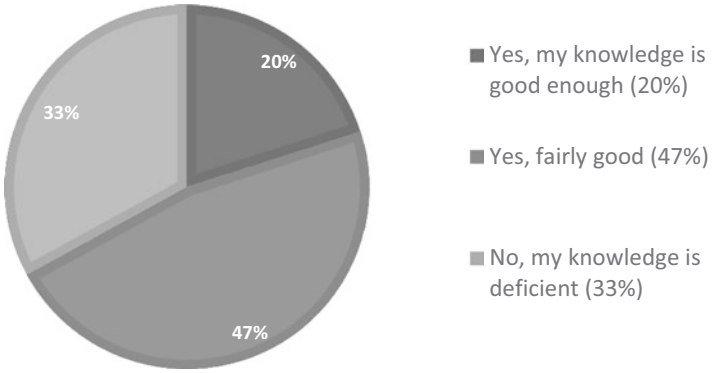


Fig. 8 Result from the question "Do you consider yourself to have knowledge to make a consciously more sustainable choice to get clothes for an outdoor adventure?"

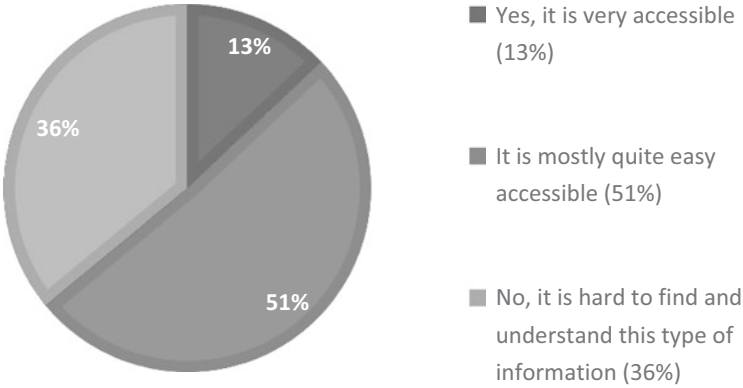


Fig. 9 Result of the question: "Do you consider information on how to make a more sustainable choice of clothing before an outdoor adventure to be easily accessed, for example by asking staff in a store or by doing research on your own online?"

knowledge in this area for more consumers to be able to make more conscious choices in the future.

The survey questions regarding knowledge and access to information on how to make a more sustainable choice for an outdoor adventure, were in the project put into relation to the respondents' feelings towards renting outdoor clothing. The result showed that the most common is a positive feeling toward renting outdoor clothing no matter how the respondents rated their knowledge on sustainable consumption in outdoor clothing. The result also showed how the group that finds information on more sustainable choices in the researched area harder to find, also is a group that is more likely to not have positive feelings or thoughts on the rental model.

4 Discussion

Understanding consumer behavior, from a SPT-perspective, clarifies challenges and concerns for making rental an alternative to purchasing outdoor equipment (Fig. 10).

The factors in Fig. 10 are further discussed in Sects. 4.1, 4.2 and 4.3 below in terms of consumer needs, corporate perspectives of meeting rental requirements and finally the resource implications of rental.

4.1 Consumer Needs in a Rental Service

The results of this study point to the environmental benefits seen by many of the respondents. There is also a pattern in the answers of the respondents stating to be more positive towards the rental model, and the group wanting to share their practices of the way to consume rented outdoor clothing with friends and comments about the environmental benefits of rental.

Looking at previous studies on the rental model, it is not clear that the rental model always is the most sustainable choice. This depends on geographical location

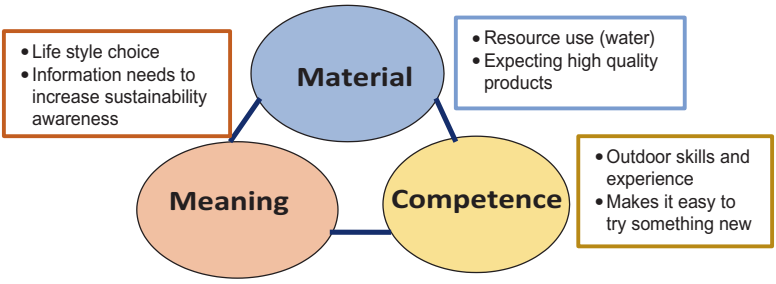


Fig. 10 An overview of factors that influence the consumer rental practices

for example, as raised in the analysis of the material element. For this model to be environmentally beneficial, the location of the rental is crucial, to decrease the transportation connected to the rental. Martin et al. (2021, 15) concluded in their work that the rental service has the potential of better utilizing the service lifetime of the produced products. The full potential of the rental service could be accessed if the focus is on reducing additional transport for accessing and maintaining the service.

Consumption frequency also determines consumer needs for rental of ownership (Mont, 2004). The result of this study shows that people who are more experienced in their outdoor activity often practice their outdoor activity more often, and thereby need their outdoor clothing more often. This group of people, no matter the activity, value owning their outdoor clothing for both economic and logistic reasons. Some people in this group, especially the hikers, also use their outdoor clothing in their daily life. The reason for this to differ some, compared to the skiers, is likely the type of gear. It is easier to use hiking clothing when not hiking, than for skiers to use skiing clothing often produced to manage colder and harder weather conditions. According to studies in line with the one from LUT University in Finland (Berge, 2021), it is not only beneficial for the individuals in this group for economic and logistic reasons to own their clothing, but this is also the best solution for the environment. This is explained by frequency in use as well as hygiene expectations that could lead to frequent washing in a rental alternative.

It is also likely the group being positive towards the rental model has not considered the possible increase in consumption that rental could open up for as shown by Lang and Joyner Armstrong (2017). Being able to rent offers opportunities to consume more, but also to make more informed choices when purchasing an item. Johansson and Nilsson (2016, 23) argue we (consumers) need to buy less clothing and textiles, *and* make sure the clothes we no longer want, or need are being reused or recycled, to make the current system better. However, the rhetorical question remains unanswered—can consumers be expected to have knowledge about sustainability effects of a purchasing or rental alternative? Or should institutional economic conditions make it easy to do the "right thing." We just need to figure out what the right thing is.

There are more hikers in the survey than respondents doing the other activities in the survey, which might can be explained by the time of year the survey was done, during the spring, as a peak season for hiking. There are now more customers in the store looking for hiking products for the upcoming summer than for example customers looking for skiing clothes. It would be interesting to do the survey in time before the winter season too if the need for a wider result connected to rental clothes for winter activities is needed.

Societal norms are reflected in legislation and practices. These norms can change gradually as consumer awareness of sustainability challenges (meanings in SPT) rise. Influencers such as the sustainability icon Greta Thunberg gives sustainability challenges related to consumption of fast-moving consumer goods, such as cloths. Greta Thunberg and other famous people may serve as ambassadors and change agents. This is supported by findings by Shrivastava et al. (2021). They point to the

importance of social media, especially influencers' capacity to establish platforms that promote circular fashion and sustainability.

4.2 Critical Issues to Develop Rental Services from a Corporate Perspective

Critical issues for developing a rental based business model from a corporate perspective relates to how value is created, the revenues and the expectations of profit. This project points to consumers' appreciation of easy access, which is supported in studies of rental business models (Nyvall et al., 2023), and consumers' frequency in use as key factors for assessing the business model.

The importance *availability* of a service offer has been especially clear at times of COVID (2019–2022). As a result, purchasing online has increased for fast moving consumer goods, such as food and textile. Availability can be achieved through clear web pages, easy rental procedures, nearby pick up or delivery services and a flexibility that allows for consumers to try on garments in the store, or order online.

From a corporate perspective, *frequency of use* is reflected in needs to purchase a product, extend the product lifetime in services, upgrade the offer and offer new products when the original has been worn out. This is traditionally evaluated in terms of transactions and short-term profits. A relationship marketing perspective, however, would see these transactions as opportunities to get to know the consumer, the needs, expectations, and experiences. A rental situation offers an opportunity to develop a relationship, that can be followed up when the rented item is returned. This information may prove valuable for continued product development, as well as future service offers for the consumer.

Guiding the consumer in his or her consumption as part of relationship marketing. If a garment is only used one time, The Swedish Environmental Protection Agency (2022c, 3) recommends renting the clothing. When and if renting outdoor clothing, it is important for the respondents in this study to have easy access to this choice and the model should fit their lifestyle in relation to their way of spending time outdoors. Most people want to pay per product and to try the clothing in a physical store, to make sure they rent something that fits them and the planned activity. The second most wanted way to rent the clothing is to order online and pick the clothing up at the nearest delivery service. For the rental model to be desirable, the renting process needs to be as easy as possible. Added comments to the result also say renting the clothes in the resort where the outdoor activity is performed is valuable. To raise the possibility of renting outdoor clothing, a renting clothes section could be a part of the physical stores. Thereby, social benefits can be reached by making it easier and more accessible for beginners to try a new outdoor activity for the first time when the first investment to try something new is less likely to be the factor of not trying the activity in the first place. With the trend of more people enjoying the outdoors because of the COVID-19 pandemic (The Swedish

Environmental Protection Agency, 2022b), it would be interesting to see the trend continue but in a more sustainable way, if possible.

Harper (2022) points to corporate challenges related to small scale in high-cost contexts. This concerns production (small series) as well as sales (retail). In our study, 21.8% of the respondents expect the rented clothing to look brand new. A rental business model may serve as a driver for development of lasting products, that have a new appearance for a long time in use. Small scale and consumer expectations of lasting quality are seen as cost drivers.

4.3 Resource Implications in a Rental Service Offer

The empirical study points to concerns related to resource use in a rental service offer. Our respondents, the consumers, verbalize availability needs of the cloths which points the importance of location of the rental service as well as open hours. The cloths item is also expected to be clean, which points to needs for washing and weather proofing on a regular basis. This project did not set out to map resource use or to do a life cycle-analysis of how rental compares to purchasing a product. We have identified various resource, such as water use, cleaning agent, weather-proofing agent related to just the cleaning of cloths that has been rented.

Mistra Future Fashion (2019, 19) state in their report rental or borrowing apparel for outdoor activities appears to be a partial solution to sustainability challenges. However, increased transportation because of the rental business model can offset the benefits gained from reduced production therefore, location for renting clothes is important, and collaborative consumption might not be suitable for all kinds of clothing.

5 Conclusions – Understanding Rental from an SPT Perspective

This project investigated the consumer perspective on renting clothes, more specifically clothes for outdoor activities. The aim of the research project was to explain consumer perspectives on renting outdoor clothing. Implications of this study may pave the way for developing a more consumer focused rental business model in the industry. Focus was placed on consumer attitudes of consumers that visited the Haglöfs retail store in Stockholm. With an ambition to understand consumer's practices, rental of cloths at a particular time, social practice theory (**SPT**) served these needs well. Questions were focused on the three elements of practice: materials, meanings, and competence with an open mind of additional elements that the SPT may not cover.

5.1 Materials

The result of the data collection in the *material* dimension of SPT shows that beginners or consumers with average frequency in their outdoor activity/activities are more likely to rent their outdoor clothing than people being experienced outdoors, because of logistic and economic reasons. Previous studies on the rental model in the clothing industry also point out that the rental service most likely is not an attractive alternative from a sustainability perspective for experienced frequent users of a particular garment.

If rental is an alternative, it needs to be easy and accessible and the result points out that a physical store and paying per product is the most desired rental model. To minimize the need for longer transportations connected to the rental, like ski rental by the slopes, a physical store near the planned outdoor activity is preferred, for logistic benefits for the customer but mostly to sustain the environmental benefits of the rental model.

The *material* result also points at possibilities for a stronger relationship between a brand and its customers, and that outdoor brands with a linear business model today can increase the lifetime of garments if they combine their current business model with the rental model that let customers rent clothing and try them for their right purpose before purchasing them. On the other hand, letting customers try out the clothing through rental could also lead to an increased consumption rate when creating a desire for new outdoor clothing the customer may not planned to buy in the first place. The rental model in general could lead to a faster consumption rate when giving access and ability for customers to always wear the latest outdoor clothing on the market.

5.2 Meanings

In the *meanings* dimension, the result shows that the respondents see the benefits of the rental model, either for themselves or for someone else, and that if the respondents rent their outdoor clothing, they want to inspire their friends to do the same in the future, especially among female respondents. The women in this study also have more positive feelings towards the rental model than men. Among all the respondents, the environmental benefit is wanted, but so is the look and the function of the outdoor clothing. The rental model could lead to more people finding outdoor activities and being able to try these for the first time when they are easier accessible, and these types of social benefits are important to many of the respondents.

5.3 Competence

Looking at the *competence* dimension, the bigger part of the respondents stated to have the needed knowledge to make a more sustainable choice of clothing for their outdoor adventures. However, the results also point to a risk of even the groups rating their knowledge in the area to be high, may lack valuable information to make more sustainable consumption choices for their future adventures. This points to an opportunity for outdoor clothing brands could increase the knowledge among people by educating their employees on more sustainable choices for customers, to make information easier to find for customers.

5.4 What Have We Learned? Suggestions for Future Research

This study set out to explain consumer perspectives of outdoor cloths rental as an alternative to purchasing the cloths. Using a SPT perspective puts the focus on the *practices* to investigate what the enhancing and hindering factors are for rental to be a realistic alternative to purchasing a product.

In a relationship marketing perspective of services, rental offers opportunities to develop a relationship between the corporation (producer of cloths and or retail business), which may lead to product development opportunities, customer loyalty and less resource use to meet customer needs of outdoor cloths without compromising their needs to exercise these activities.

This study points to renting outdoor clothing depends on businesses that use an alternative business model (to the transaction-oriented purchasing model). From a corporate perspective, a triple bottom line needs to be reflected in the development of a service offer, for example:

- From an environmental perspective, the rental needs to be geographically placed to minimize the transport.
- The social dimension includes considering the outdoor experience and needs in developing the rental offer.
- The economic (or financial) aspect of the rental offer means the business needs to take a relationship marketing perspective in the needs to balance the return on investment when developing a rental model.

Future research opportunities are seen in interdisciplinary comparative studies of environmental, social, and financial dimensions of rental as an alternative to purchasing fast moving consumer goods. What do we, as consumers, need to own? And how willing are businesses to provide the services that a rental business model implies? This study was conducted in a particular context at a particular time. It would be interesting to see how the understanding of rental develops over time, in different cultural contexts. Public health efforts are made to increase physical activities. If these needs can be met with rental, it would open for more consumers to do more outdoor activities.

Appendices

Appendix A: Signs in the Store

Appendix B: Survey – Renting Clothes for Outdoor Activities

My name is Lovisa and I am writing my master thesis at Uppsala University about customers attitude towards renting outdoor clothing. The aim of the research project is to understand customers attitude towards renting outdoor apparel, to be able to develop a more customer focused rental business model in the industry, and thereby make a more sustainable consumption choice more accessible and appealing to customers. It would make me very glad if you took a couple of minutes to answer the following 15 questions. You are anonymous in your participation of the study.

Thank you for your time!

1. Age
2. Gender
3. What kind of outdoor activities do you do?

4A. Level of skier

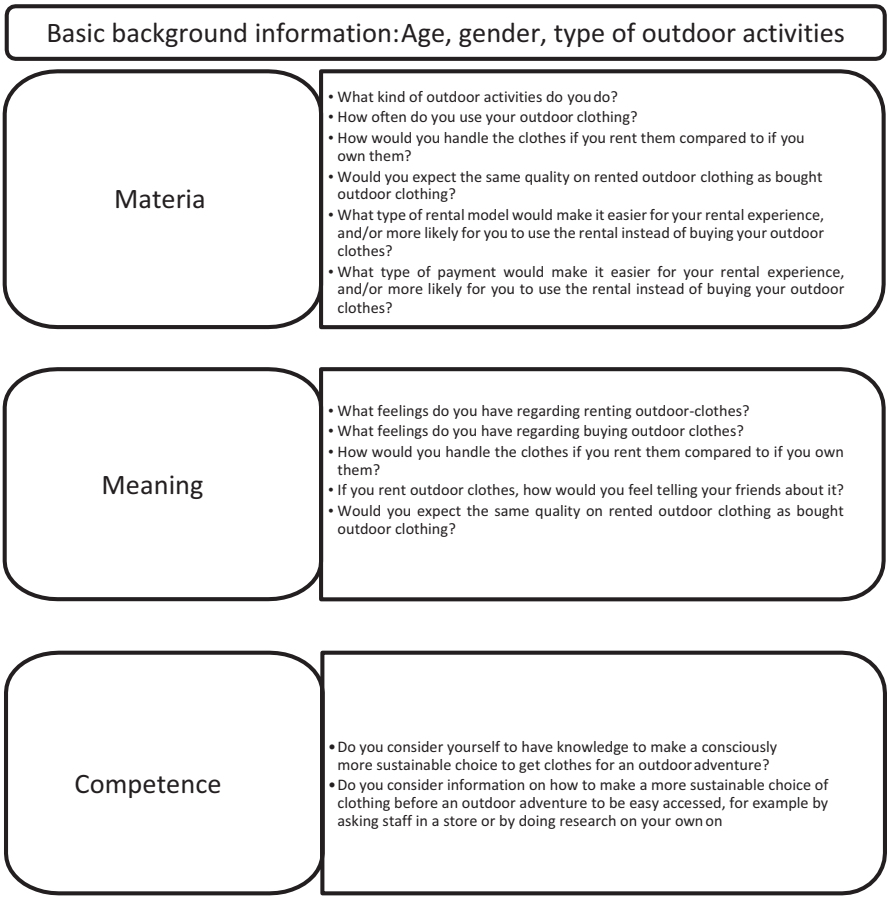
4B. Level of hiker

4C. Level of camper
4D. Level of biker
4E. Level of mountaineering
4F. Level of other activity, please write the type of activity with your answer
5. How often do you use your outdoor clothing?
6. What feelings do you have regarding renting outdoor-clothes?
7. What feelings do you have regarding buying outdoor clothes?
8. How would you handle the clothes if you rent them compared to if you own them?
9. If you rent outdoor clothes, how would you feel telling your friends about it?
10. Would you expect the same quality on rented outdoor clothing as bought outdoor clothing?
11. Do you consider yourself to have knowledge to make a consciously more sustainable choice to get clothes for an outdoor adventure?
12. Do you consider information on how to make a more sustainable choice of clothing before an outdoor adventure to be easy accessed, for example by asking staff in a store or by doing research on your own online?
13. What type of rental model would make it easier for your rental experience, and/or more likely for you to use the rental instead of buying your outdoor clothes?
14. What type of payment would make it easier for your rental experience, and/or more likely for you to use the rental instead of buying your outdoor clothes?
15. Do you have any other thoughts concerning rental that you would like to share with me? Thank you so much for your contribution.
16. Do you want to take part of the result of this study? Would you like to participate in the lottery of a Tight Backpack from Haglöfs?

- Yes, I would like to get an invite to the seminar in Uppsala and will receive more information about this later on my email.
- Yes, I would like to participate in the lottery of a Tight Backpack from Haglöfs

Your email address if you answered yes in any of the questions above. Your email address will not be used for any other purposes or be used in the report.

Appendix C: Survey Questions on Social Practice Theory



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Does Textile Recycling Reduce Environmental Impact? A Probabilistic and Parametric Analysis for a Case of Open-Loop Recycling

Audrey Tanguy and Valérie Laforest

Abstract In recent years, textile recycling has emerged as an important strategy for reducing the environmental impact of supply chains for various products. But the environmental benefits of recycling might not be systematic, and it is useful to know under which conditions using recycled textile fibers is preferable than virgin materials. The objective of this study is to investigate the potential of textile recycling to reduce environmental impact using a probabilistic life cycle assessment (LCA) approach, applied to a case of open-loop recycling to replace virgin thermoplastics by polyester textiles. The variations of some sensitive parameters are used to test their influence on the probability of the recycling scenario outperforming the reference one using virgin materials. The parameters evaluated are the waste collection distance, the product distribution distance, the amount of additives added to the recycled fibers, the replacement rate, and the origin of the substituted reference product. Out of the 18 impact categories assessed, the recycling scenario outperforms the reference one for eight of them and for every instance of calculations. On the contrary, for other categories, the product made from recycled fibers presents greater environmental impacts, even when large background uncertainties are considered. Therefore, multicriteria assessment is highly recommended when assessing the environmental impact of textile recycling. Well-studied parameters such as the replacement rate or the substituted product's origin affect confident decision-making for seldomly studied, local impact categories such as terrestrial ecotoxicity. While demonstrated here for a specific case of open-loop recycling, these results can be generalized to other cases where used textile substitutes virgin plastic materials.

Keywords Textile recycling · LCA · Uncertainty · Influential parameters · Environmental impact · Open-loop · Polyester recycling

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1 Introduction

From 2000 to 2014, global clothing production has increased by 100%. Nowadays, an average consumer buys 60% more clothes and uses them half the time than 15 years ago. These changes in consumption behavior generate a great amount of textile waste (Islam & Bhat, 2019). In 2019, in Europe, only 26% of these waste flows were recycled (Islam & Bhat, 2019). There rest was landfilled, which contributes to environmental pollution including groundwater contamination and greenhouse gases release during decomposition (Dissanayake et al., 2018).

Circularity is currently a central strategy of the textile sector to implement its transition towards sustainable production (Harmsen et al., 2021). The European Union released recently its strategy for sustainable and circular textiles that encompasses "actions to ensure that by 2030 textile products placed on the EU market are long-lived and recyclable, made as much as possible of recycled fibers, free of hazardous substances and produced in respect of social rights and the environment"(European Commission, 2022). A quick search on Scopus using the term "circular fashion" led to 31 results, with the highest number of papers published in 2021. Circularity in the textile industry is thus gaining momentum and, with it, the well-known R strategies of the waste hierarchy (Reduce, Reuse, Recycling).

Recycling is especially put at the forefront of circular endeavours (Pensupa, 2020). In recycling value chains, the textile fibers can keep their initial function via closed loops (Braun et al., 2021) or they can be used for another function or product in open loops (Rahman, 2022). In both cases, the focus is to reduce the amounts of discarded textile waste by creating and substituting new resources, i.e., to retain the material intrinsic value of textile fabrics and garments (Haupt & Hellweg, 2019). However, increased circularity and reduced environmental impact are not synonyms and many of the circularity assessment frameworks lack quantitative metrics to include the environmental impacts of circular strategies such as recycling (Haupt & Hellweg, 2019).

Sandin and Peters (2018) published a review paper on the potential environmental benefits of textile recycling and reuse. Analyzing the findings of 41 publications, the authors noted that, generally, recycling was preferable than incineration and landfilling and that the use of recycled fibers was less impactful than the manufacturing of new products. However, their study revealed also some cases for which recycling was not preferable. For example, the use of fossil energy in the recycling process can be a cause for greater environmental impact (Sandin & Peters, 2018). The study of Liu et al. (2020) presented seven impact categories for which recycled cotton had a greater environmental impact than virgin cotton, but without investigating further. Therefore, the environmental benefits of textile recycling might not be systematic, which is reinforced by the fact that a limited number of impact categories are assessed in most studies conducting life cycle assessments (LCA) (Peters et al., 2019; Sandin & Peters, 2018). To the authors' knowledge, no study has yet analyzed the environmental prevalence of textile recycling, considering the

influence of different parameters, an uncertain background context and different impact categories.

The objective of this chapter is to investigate the potential of textile recycling to reduce environmental impact using a probabilistic and parametric analysis to obtain robust conclusions for an open-loop recycling case (polyester recycling to manufacture a new product). More particularly, we investigate the influence of some well-studied parameters, such as the replacement rate, on the probability that textile recycling outperforms a reference scenario, without recycling, for 18 impact categories. Conducting this analysis allows highlighting the conditions that might constraint the possibility of recycling to present environmental benefits for a specific case study, e.g., an impact category or a too uncertain influential parameter.

This chapter is structured as follows. First, a brief literature review on the environmental impact of polyester recycling is presented. Then, the second part describes the methods, including the recycling LCA model and the probabilistic approach. The comparative results are detailed for the deterministic and probabilistic analyses. Finally, the environmental benefits of textile recycling are discussed along with the advantages and limitations of the uncertainty analysis performed in this study.

2 Literature Review

The textile sector includes three main types of fibers: (1) natural fibers produced from natural resources such as cotton and wool (2) regenerated fibers derived from natural polymers, but requiring treatment and processing (3) synthetic fibers mainly derived from petrochemical (and therefore non-renewable) resources such as polyester, polypropylene and nylon (Shirvanimoghaddam et al., 2020).

Textile recycling refers to the treatment of pre- or post-consumer textile waste for use in new textile or non-textile products (Sandin & Peters, 2018). Recycling involves different types of routes such as mechanical, chemical or thermal. Combinations of these three routes are usually used for three types of recycling: fabric recycling (product to product), fiber recycling (the fabric is disassembled, but the original fibers are preserved), polymer/oligomer recycling (the fibers are disassembled, but the polymers or oligomers are preserved) and monomer recycling (the monomers are preserved) (Sandin & Peters, 2018).

Life cycle assessment has been widely used to assess the environmental impact of various textile recycling techniques and scenarios (Muthu, 2015). In their literature review, Sandin and Peters (2018) noted that the most frequently assessed cases were cotton and polyester recycling with fiber recycling being the most studied recycling route. In the case of polyester recycling, closed-loop scenarios are often assessed (Muthu et al., 2012; Spathas, 2017; Zamani et al., 2015) along with some examples of open-loop systems (Intini & Kühtz, 2011). One common methodological choice is the expansion method to account for the avoided impact of virgin materials and incineration and/or landfilling. Since polyester derives from fossil fuels, many studies report environmental benefits from polyester recycling for

primary energy consumption, global warming and terrestrial acidification (Zamani et al., 2015; Spathas, 2017; Schmidt et al., 2016).

Nevertheless, most of the reviewed studies are deterministic analyses, i.e., they do not account for uncertainties that may hamper the robustness of the conclusions. Uncertainty in LCA has become a hot topic in recent years (Igos et al., 2019), especially when conducting comparative LCAs (Gregory et al., 2013; Mendoza Beltran et al., 2018). Including uncertainties in such analyses can (1) improve the level of confidence of decisions regarding the preferred scenario, (2) determine whether the difference observed is actually significant and (3) enable the exploration of a broad range of possible combinations of all sorts of input data (Mendoza Beltran et al., 2018).

3 Materials and Methods

3.1 The Recycling LCA Model

This study conducts a comparative analysis of two alternatives for sport plot production that will be commercialized and used in Europe. The first alternative is a production based on polyester recycling of discarded sport jerseys, located in France. The recycling process modelled in this comparative LCA is based on the process developed by industrial partners who gave all relevant technical data. The second alternative, called the reference scenario, is the conventional production of sport plot using primary polyvinyl chloride (PVC) that is manufactured in China. The goal and scope of this LCA and data sources are further described in the next sections.

3.1.1 Functional Unit

Two functions are considered to compare the scenarios: the treatment of used sport jerseys and the supply of sport plots.

The functional unit is therefore to treat 16,000 used sport jerseys (about 1920 kg of used polyester) and to manufacture 160,000 sport plots with their support bars.

3.1.2 System Boundaries

This study is a cradle-to-gate analysis, i.e., it includes only the upstream stages of the plot production when the plots are ready to use. Indeed, it is assumed that the plot production strategy (using recycled fibers or not) does not influence a plot's average lifetime. The product made from recycling sport jerseys is designed according to the robustness criteria relevant for this product category. This assumption will

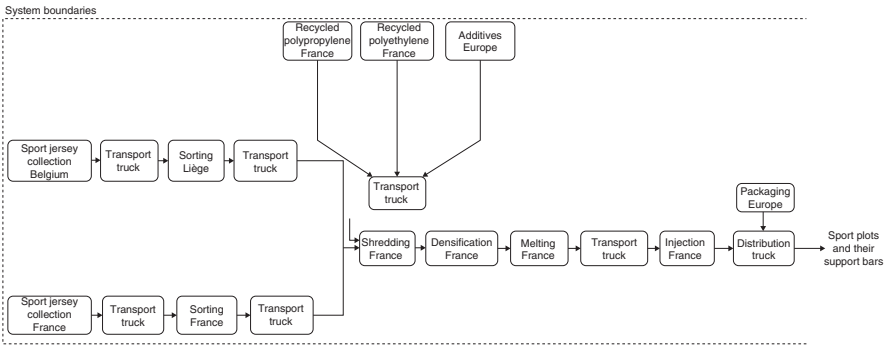

Fig. 1 System boundaries for the recycling scenario

be however tested in the sensitivity analyses. Moreover, the distribution stage is also included because the transportation distances and modes vary between the two scenarios.

Figure 1 shows the system boundaries for the scenario using recycled textile fibers, which will be called "recycling scenario" in the rest of the chapter.

The scenario includes the jersey collection at various collection points such as sport clubs, sport events and stores in France and Belgium. The jerseys are then sorted in French or Belgium facilities, with a sorting efficiency of 93%. All the waste jersey flows are transported to a French facility where they undergo a thermo-mechanical treatment involving the shredding of the polyester fibers, their densification and melting to form plastic granules. For the melting process, other materials and chemicals are added to the compound to ensure the technical performance of the final product. In this case study, recycled propylene (PP) and recycled polyethylene (PE) are used as well as other organic chemicals, not disclosed here for confidentiality reasons. The recycled plastics come with no upstream environmental burden, as per the cut-off approach. Only the impact of the waste collection and recycling into PP or PE granules is accounted. The efficiency of the whole treatment process is 91%. The granules are then transported to an injection plant where the plots get their final form. They leave the plant to be distributed and commercialized in Europe.

Figure 2 represents the system boundaries for the reference scenario, in which conventional sport plots are manufactured. To assess functionally equivalent systems, the reference scenario includes the end-of-life treatment of the sport jerseys in the case they are not used for sport plots production. They can be landfilled or incinerated without energy recovery or recovered to get new materials or energy. If so, these environmental benefits are not accounted in the system boundaries according to the cut-off approach.

The conventional route to manufacture sport plots which are the most frequently found on the French market is PVC production and injection in Chinese plants. PE is used for the bar production process. The sport plots and their support bars are then transported in sea containers to a French harbour and by truck to the final

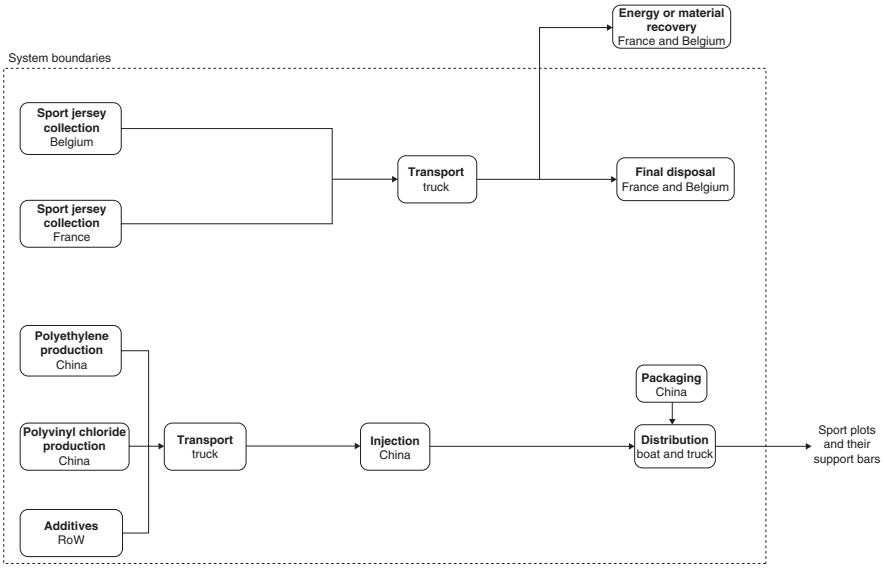

Fig. 2 System boundaries of the reference scenario

destination, which is the same than the recycling scenario. According to the industrial partners of this study, conventional sport plots manufactured in Portugal can also be found in the market. This assumption will be tested in the sensitivity analyses.

3.1.3 Data Collection and Sources

The main data sources are presented in Table 1. Primary data which are specific to the case study are related to (1) the sport jersey collection and (2) the polyester recycling process developed by the industrial partners. Secondary data come mainly from the ecoinvent v.3.8 database using the cut-off system model. They refer to the unit environmental impact of transport, sorting, the recycling of PE and PP in the recycling scenario, the additives production process, the injection process and landfilling. The dataset of the plastic injection stage has been modified to reflect the French and Chinese electricity mixes (or Portugese for the sensitivity analyses). For the reference scenario, data on the end-of-life treatment of used textiles were retrieved from material flow analysis studies conducted in Belgium and France which reported the current final disposal rates at the national level. Tables 2 and 3 present the foreground data for both scenarios.

Table 1 Data sources

Life cycle stages	Primary data sources	Secondary data sources
Resource extraction and transformation		For both scenarios: ecoinvent v.3.8 (cut-off)
Resource transport		
Material production (PE, PVC, additives)		
Jersey collection	Collected quantities and distances given by the industrial partners	Transport unit impact: ecoinvent v.3.8 (cut-off)
Jersey sorting		ecoinvent v.3.8 (cut-off)
Recycled PE	Quantities and origin given by the industrial partners	Recycling unit impact: ecoinvent v.3.8 (adaptation du mix électrique)
Recycled PP	Quantities and origin given by the industrial partners	Recycling unit impact: ecoinvent v.3.8 (adaptation du mix électrique)
Polyester recycling (shredding, densification, melting)	Quantities, energy consumption and process efficiencies given by the industrial partners	Additive unit impact: ecoinvent v.3.8
Injection		For the recycling scenario: ecoinvent v.3.8 (cut-off) dataset adapted with the French electricity mix + removed additive inputs (already present in the recycling process) For the reference scenario: ecoinvent v.3.8 (cut-off) dataset adapted with the Chinese electricity mix
Distribution	Distances with Google Maps	Transport unit impact: ecoinvent v.3.8 (cut-off)
Jersey end-of-life treatment (Reference scenario)		Payet (2021) for France and Dupont (2018) for Belgium + ecoinvent v.3.8 (cut-off) for landfilling unit impact

Table 2 Foreground data for the recycling scenario

Life cycle stages	Parameter	Unit	Value
Jersey collection	Distances Transported amount Transport mode	km kg N.A.	1803 2280 Camions (EURO4)
Jersey sorting	Process efficiency	%	7
Recycled PE and PP	Mass Supply distance	kg km	3613 773 (PE), 112 (PP)
Polyester recycling	Additives Electricity consumption Water consumption Process efficiency	kg kWh m^3% 	1051 4132 93 9
Distribution	Distances Transported quantities Transport mode	km kg N.A.	800 6480 Trucks (EURO4)

Table 3 Foreground data for the reference scenario

Life cycle stages	Parameter	Unit	Value
PVC production	Amount	kg	6438
PE production	Amount	kg	201
Distribution	Distances (truck EURO4)	km	300
	Distances (cargo ship)	km	20,000
	Transported amount	kg	6600
Jersey end-of-life treatment	Final disposal rate (France)	%	34
	Final disposal rate (Belgium)	%	0
	Transport distance to landfill	km	50

3.2 The Probabilistic Approach

3.2.1 Uncertainty Characterization

The LCA literature distinguishes between three main sources of uncertainty: parameters (data quantities), scenarios (normative choices) and the model (mathematical relationships between the parameters) (Lloyd & Ries, 2007). Within each source, the nature of uncertainties is also diverse (Igos et al., 2019): they can be stochastic, i.e., they come from an inherent variability, or epistemic, arising from a lack of knowledge or representativeness (spatial, temporal, or technological).

In this work, the uncertainty characterization is based on the uncertainty data provided by the ecoinvent database V3.8. These data are provided thanks to Pedigree values that are available for each input of each dataset. These semi-quantitative assessment of epistemic uncertainty is then converted to lognormal distributions, which are used for the uncertainty calculations with the software (Muller et al., 2016). Therefore, this study considers only background epistemic parameter uncertainty. The Pedigree values of the modified datasets (indicated in Table 1) were modified accordingly.

3.2.2 Uncertainty Propagation and Calculations

The uncertainty propagation is performed with the SimaPro software v9.3, using the uncertainty analysis function. SimaPro uses the Monte Carlo simulation method to create a sampling of inventory data inputs. When two systems are assessed simultaneously during an uncertainty analysis, the sampling is dependent, i.e., at each Monte Carlo run, the same values of the technology and environmental matrices are fed to calculate both inventories. The impact results of each system are then stored and compared. In this study, 5000 Monte Carlo runs were performed for each uncertainty analysis.

SimaPro uses a discernibility analysis to quantify the statistical significance of the comparative results (Mendoza Beltran et al., 2018). It means it calculates the probability (P_R) that one system is superior to the other based on the number of runs said system had a lower environmental impact than the other. Equation 1 shows the

calculations of P_R for the impact category i (Mendoza Beltran et al., 2018). One disadvantage of this method is that it disregards the distance between the mean scores (Mendoza Beltran et al., 2018).

$$P_R = \frac{\#_{r=1}^{5000}\left(\text{Impact}_{i,\text{Rec},r} - \text{Impact}_{i,\text{Ref},r} > 0\right)}{5000} \quad (1)$$

Where # is the symbol of the counting function, r is the index of the Monte Carlo simulations ($r = 1,\ldots,5000$), $\text{Impact}_{i,\text{ Rec},r}$ the impact result of the recycling scenario for the category i and $\text{Impact}_{i,\text{ Ref},r}$ the impact result of the reference scenario for the category i.

3.2.3 The Sensitivity Analysis of the Probabilistic Results

The conditions that frame the environmental performance of textile recycling are represented in this study by the min-max variations of different parameters. These parameters and their min-max intervals are presented in Table 4. Some parameters are numerical, e.g., the average waste collection distance, while others are categorical, e.g., the substituted product's origin. The selection of these parameters is based on both a literature review of textile recycling LCAs that identified these parameters as influential and the specific context of the study for which some inventory parameters were quite uncertain.

The sensitivity analysis is performed in two steps. First, a best- and a worst-case analyses are conducted to assess the min-max variation of P_R. The best-case analysis is the most favorable to the recycling scenario (all parameters have their min values) while the worst-case analyses is the least favorable (all parameters have their max values). This first step allows for discriminating categories for which P_R does not vary, i.e., categories for which the performance of textile recycling is not sensitive to the selected parameters.

Second, sensitivity analyses are conducted on the remaining impact categories by varying the parameters individually while keeping the other parameters at their mean value. This step allows to observe the sensitivity of P_R to each parameter.

Table 4 Selected parameters for the sensitivity analysis

Parameters	Min-Max intervals	Mean value	Unit	Sources for the parameter's choice
Waste collection distance	[300–1200]	600	km	Case study
Sport plot distribution distance	[100–1500]	800	km	
Additive quantity in the polyester recycling process	[901–1201]	1051	kg	
Replacement rate	[1:2–2:1]	1:1	–	Sandin and Peters (2018)
Substituted product's origin	Portugal, China	China	–	Peters et al. (2019) and Zamani et al. (2015)

4 Results and Discussion

4.1 Comparative Results Using a Determinist Approach

Figure 3 shows the normalized impacts of the recycling and conventional scenarios. The results in absolute values are presented in the Appendix (Table 5).

For almost all the impact categories (17/18), the relative impact difference between the two scenarios is more than 20%, except for freshwater ecotoxicity. These gaps can be considered significant in a deterministic analysis. Therefore, we may conclude on the superiority of one scenario for these 17 categories.

The recycling scenario performs better for 14 impact categories. The gap is especially large (over 60%) for categories relating to atmospheric emissions (global warming, stratospheric ozone depletion, ground-level ozone formation, fine particle formation), terrestrial acidification and human non-carcinogenic toxicity. These results are consistent with the findings of Zamani et al. (2015) who compared the global warming impact of recycled polyester fibers and virgin polyester manufactured in China. The substitution of virgin petrochemical compounds such as PVC allows for significant fossil fuels and chloride emissions savings, which explain the large differences between the two scenarios. Furthermore, these results suggest that avoiding PVC production may lead to a significant decrease in water consumption, such as in the study of Spathas (2017).

The impact of the recycling scenario for the ecotoxicity categories (terrestrial and marine) is a little bit more surprising. The source of this impact is road transportation by trucks, which causes heavy metal dissipation on the roadway due to the tire abrasion. The recycling scenario includes more road transportation, to collect waste and distribute the final products, than the reference scenario, which relies instead on maritime transportation by cargo ships (from China to Europe). Some

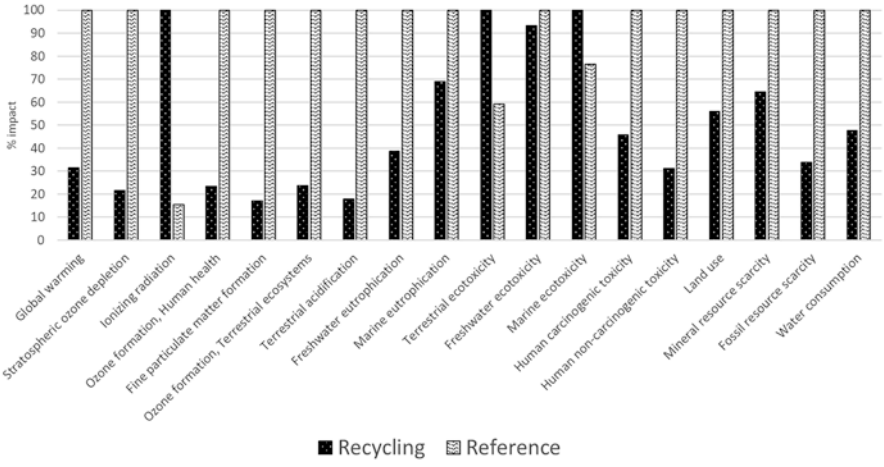

Fig. 3 Normalized impacts of the recycling and reference scenarios

studies found transportation activities to have insignificant impact in closed-loop (Liu et al., 2020) and open-loop scenarios (Shen et al., 2011) of recycling systems. But these studies either did not consider or did not investigate further the ecotoxicity categories. The influence of transportation distances will be tested in subsequent sensitivity analyses.

4.2 Comparative Results Using a Probabilistic Approach

4.2.1 Best- and Worst-Case Scenario Analysis

Figure 4 shows the pair-wise uncertainty analyses of the midpoint impact categories. The black bars express the probability that the scenario using recycled textile performs better than the reference scenario using virgin materials (P_R). The results are illustrated on two extreme cases (best and worst case), which represent the parameters' variation ranges.

Parameter uncertainty influences the recycling scenario's performance but does not always imply a change in the preferred scenario. A previous study considered that a probability (P_R) higher or equal to 80% is enough to select a scenario with a high level of confidence (AzariJafari et al., 2018).

For nine impact categories, the conclusions on the preferred scenario remain unchanged in comparison to the determinist analysis presented in Sect. 4.1, i.e., for global warming, stratospheric ozone depletion, ionizing radiation, ozone formation—human health and terrestrial ecosystems, fine particulate matter formation, terrestrial acidification, freshwater eutrophication and fossil resource scarcity. Indeed, the difference between the recycling and reference scenarios is 100%, suggesting that the recycling scenario performs better in nearly every instance of calculations. These impact categories are mainly driven by the PVC production process in the reference product's supply chain, except for ionizing radiation, which depends on the French electricity mix used in the recycling scenario. Therefore, results for these categories are not directly affected by the parameters' variations.

Water consumption offers an example of a probabilistic analysis that contradicts determinist calculations. Indeed, despite being largely favorable to the recycling scenario in Sect. 4.1, Fig. 4 suggests that there is no preferred scenario for water consumption because both scenarios present 50% of cases in which they perform better. This may be due to uncertainties related to the PVC production and wastewater treatment processes in the reference scenario, which have opposite effects on the results—PVC production contributes positively to the water consumption impact while wastewater treatment contributes negatively—but both contributions are similar in range. This result suggests that specific efforts on data collection for these background processes are required to elicit a robust conclusion for this impact category.

Figures 2a, b show a change in the preferred scenario for marine eutrophication, terrestrial ecotoxicity, human non-carcinogenic toxicity, land use and mineral resource scarcity. These categories are more influenced by the variations of the

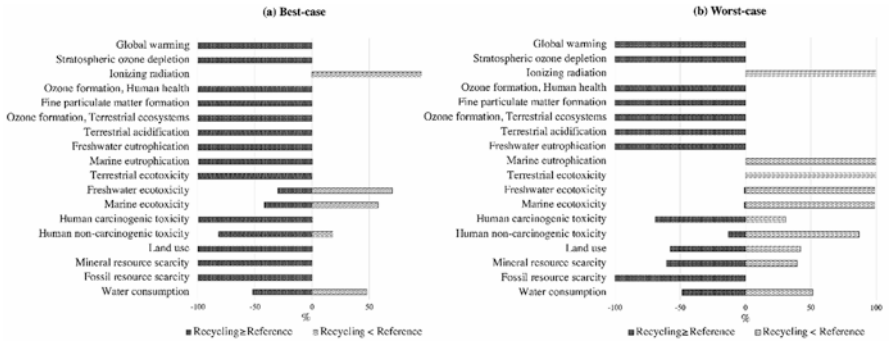

Fig. 4 Pair-wise uncertainty analyses for the best- and worst-case scenarios

parameters than by background uncertainty provided by the ecoinvent database, which was not the case for the previously mentioned impact categories. The recycling scenario performs worse for marine and freshwater ecotoxicity in both best case and worst-case scenarios, thus resolving the issue noted for freshwater ecotoxicity in Sect. 4.1.

4.2.2 Sensitivity to the Selected Parameters

Figure 5 shows the sensitivity of the comparative analysis to five parameters: the average collection and distribution distances, the additive quantity added during the recycling process, the product replacement rate and the origin of the substituted product (sport plots with virgin materials). More specifically, the variations of the probability that the recycling scenario performs better than the reference one (P_R) are presented. These variations are represented on the figure by colored boxes, whose lengths match the P_R's ranges for each impact category. Only the impact categories which showed a sensitivity on Fig. 2 were considered for this analysis.

The upper and lower probability values, i.e., the cases where the recycling scenario is superior (or inferior) to the reference scenario with a high confidence level, are indicated on Fig. 5. Within these ranges, the choice for the preferred scenario is unambiguous: either the recycling scenario performs better statistically ($P_R > 80\%$) or it performs worse statistically than the reference scenario ($P_R < 20\%$).

Figure 5 shows that P_R is highly affected by three parameters, i.e., the product's replacement rate, the origin of the substituted product and, to a lesser extent, the distribution distance in the recycling scenario. The collection distance and the additive quantity do not influence the final conclusion since the largest P_R's variation observed for these parameters does not exceed 8 points.

However, this influence is observed for a limited number of impact categories: terrestrial ecotoxicity, marine eutrophication, land use and human toxicity (carcinogenic and non-carcinogenic). Terrestrial ecotoxicity (the orange box) is the most sensitive category. There is no confident decision-making on the preferred scenario within the space of plausible values of some parameters, especially the replacement rate and the

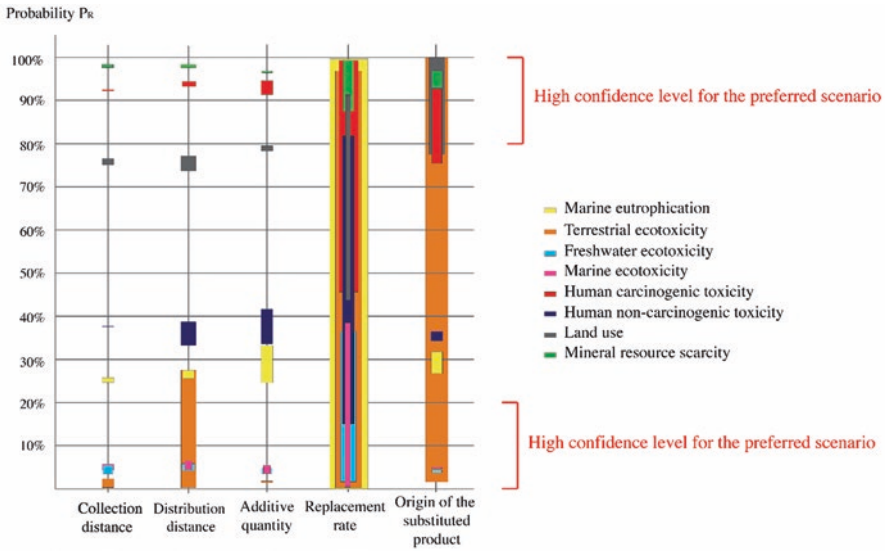

Fig. 5 Sensitivity analysis on the probability that the recycling scenario outperforms the reference one (P_R)

substituted product's origin. For example, if the replacement rate is 1:2, i.e., if one sport plot from recycled fibers is functionally equivalent to two conventional sport plots (considering that all other parameters keep their median values), the recycling scenario is preferred in 97% of cases. It drops to 0% for a replacement rate of 2:1.

For other impact categories, a high P_R variability is not detrimental to decision-making. For example, the origin of the substituted product highly influences the recycled scenario's performance on human carcinogenic toxicity, i.e., the P_R's range is close to 20 points. However, the P_R values are still close to 80%: they vary between 77% and 92%. The same observation can be made for mineral resource scarcity. This is an important reminder that a high sensitivity to a parameter's variability does not necessarily mean an impossibility to draw conclusions.

4.3 Discussion

4.3.1 Potential of Textile Recycling to Reduce Environmental Impact

Based on these study's results, the environmental benefits of textile recycling are ambiguous. This study does not support the conclusion that textile recycling is preferable *in general* (Sandin & Peters, 2018). The results showed that for some impact categories, such as marine ecotoxicity or ionizing radiation, neither background uncertainty (coming from the LCI database) nor variations of scenario parameters changed the preferred scenario, which was the reference scenario (without recycling). This specific finding is context-dependent: for ionizing radiation, recycling

is unfavorable owing to the French electricity mix, which relies heavily on nuclear energy sources. The conclusion might be different if recycling were to occur in Germany or Portugal. However, for a specific context, this study suggests that textile recycling might never become beneficial, although large uncertainties are considered. At the other end of the spectrum, for other impact categories, such as global warming, the recycling scenario performs better in 100% of cases.

This conclusion stresses the necessity to perform a multicriteria analysis when assessing the environmental performance of textile recycling (Peters et al., 2019). In their literature review, Sandin and Peters (2018) noted that impact categories such as human toxicity or ecotoxicity were assessed in only 6 and 12 papers out of 41, respectively, while climate change was almost always assessed (39 papers). This choice can lead to misleading conclusions as to the potential environmental benefits of recycling, especially regarding some of the local impact categories investigated in this study (toxicity, ecotoxicity, marine eutrophication). Results suggest that terrestrial ecotoxicity is the most affected by the variability of the scenario parameters, i.e., the parameters that recycling companies and/or the LCA experts are likely to control the most, such as the product's replacement rate or the origin of the substituted product. When high uncertainty or variability is perceived for such parameters, our recommendation is to include at least a range of plausible values when local impact categories are assessed.

The replacement rate was found influential in several studies assessing the environmental impact of recycling systems, but without threatening the environmental benefits of recycling (Sandin & Peters, 2018). For example, Dahlbo et al. (2017) found that a replacement rate of 50% (1:2) did not change the superiority of the recycling scenario on climate change, terrestrial acidification, ozone formation and particulate matter formation. Similar results were obtained in this study and reinforced with an uncertainty analysis. Considering background uncertainty and replacement rate's variability (among others), Fig. 4 shows that the use of recycling fibers remains the preferred option for these impact categories. However, this conclusion does not hold for other impact categories, not investigated by Dahlbo et al. (2017) such as ecotoxicity, land use, toxicity. In this case, the variability of the replacement rate may threaten the recycling's environmental benefits (see Fig. 5).

4.3.2 Including Uncertainties in LCAs of Recycling Systems

Treating uncertainties when conducting an LCA study helps to improve the credibility and the reliability of the conclusions (Igos et al., 2019). On the environmental impact of textile recycling, the probabilistic approach adopted in this chapter allowed to reinforce and nuance some previous observations. For example, the results confirmed the trend of the recycling scenario's superiority for impact categories such as global warming and stratospheric ozone depletion (Liu et al., 2020; Spathas, 2017; Zamani et al., 2015; Shen et al., 2011). They verified the importance of some parameters, such as the replacement rate (Sandin & Peters, 2018), not only as an influential factor but also as one factor impeding confident decision-making when its variation range is unknown. Moreover, the uncertainty analysis conducted in Sect. 4.2.1 shed

more light on the water consumption category, nuancing conclusions drawn from the deterministic analysis. In this case, an inventory regionalization should be done to decrease the uncertainty related to specific background processes (water consumption in PVC production and wastewater treatment).

Nevertheless, accounting for uncertainty to aid decision-making with LCA is a complex task and there are limitations that should be considered. First, the uncertainty analysis did not account for all uncertainty types. For example, the choice of the allocation method was constant (cut-off), although it has been stressed as one influential factor in LCAs of textile recycling and in probabilistic LCAs (Spathas, 2017; Zamani et al., 2015; AzariJafari et al., 2018). A system expansion method would have included energy recovery from incineration as environmental benefits in the reference scenario, but also the environmental benefits of using recycled PE and PP in the recycling scenario (depending on the adopted perspective). The resulting changes are difficult to predict but would have likely affected categories such as global warming, acidification and fossil fuels scarcity. Second, there are different methods for uncertainty-statistics in comparative LCAs, other than the discernibility analysis used in this study (Mendoza Beltran et al., 2018). Mendoza Beltran et al. (2018) compared five methods and showed that they concurred with each other for a majority of impact categories, except for two of them, i.e., acidification and ionizing radiation. The comparison was performed on a different case study than textile recycling, i.e., different types of motor engines, but it showed that a different method could lead to slightly different results on a limited number of categories.

Finally, borrowing the terminology from of a well-known assessment framework (Rockström et al., 2009), an interesting future study could be to map for different open- and closed-loop scenarios in different countries the "safe operating space" of textile recycling. This analysis could help to better inform decision-makers of the contexts for which recycling is highly preferable from an environmental perspective, considering even larger variations and uncertainties than the ones in this study. Advanced statistical approaches could be used, such as explorative modelling and analysis. This approach integrate large uncertainties in computational experiments to provide insights for decision-making, such as identifying specific conditions that would cause some scenarios to perform poorly (Kwakkel & Pruyt, 2013).

5 Conclusions

This chapter investigated the environmental prevalence of textile recycling on a case of open-loop recycling, considering the influence of different parameters, uncertain background data and different impact categories. A probabilistic and parametric LCA was conducted and the main conclusions may be listed as follows:

- In comparison to a product manufactured with virgin materials, a product based on recycled textile fibers might have greater environmental impact, even when large background uncertainties are considered.
- Multicriteria assessment is highly recommended when assessing the environmental impact of textile recycling.

- Well-studied parameters such as the replacement rate or the substituted product's origin affected especially local impact categories such as terrestrial ecotoxicity.
- Other parameters such as distribution distances may influence or contribute greatly to the impact of recycling but not threaten its environmental benefits statistically, i.e., the confidence in the preferred scenario.
- A probabilistic analysis may contradict clear conclusions drawn from a deterministic analysis.

Overall, a general conclusion of this chapter is to not consider textile recycling more environmentally friendly than other options *in general*, but to assess it through a multicriteria quantitative assessment and preferably through a probabilistic approach. This conclusion does not mean that textile recycling should not be promoted and further developed because this study also showed its potential environmental benefits, e.g., on global warming. However, focussing on recycling only might not be sufficient to reach a sustainable, circular fashion industry (Keßler et al., 2021). More and more studies focus on the use phase of textile, accounting for parameters characterizing consumption behavior that are levers to reduce textile environmental impact from a systems perspective (Levanen et al., 2021; Keßler et al., 2021; Schmutz et al., 2021; Klug & Niemand, 2021).

Appendix

Table 5 Midpoint results of the comparative analysis

Impact categories	Units	Recycling scenario	Reference scenario
Global warming	kg CO_2 eq	9548	30,307
Stratospheric ozone depletion	kg CFC11 eq	0,004	0,019
Ionizing radiation	kBq Co-60 eq	506	78
Ozone formation, Human health	kg NOx eq	21	89
Fine particulate matter formation	kg PM2.5 eq	8	45
Ozone formation, Terrestrial ecosystems	kg NOx eq	22	91
Terrestrial acidification	kg SO_2 eq	19	107
Freshwater eutrophication	kg P eq	0,50	1,28
Marine eutrophication	kg N eq	0,27	0,39
Terrestrial ecotoxicity	kg 1,4-DCB	46,731	27,572
Freshwater ecotoxicity	kg 1,4-DCB	11	12
Marine ecotoxicity	kg 1,4-DCB	39	30
Human carcinogenic toxicity	kg 1,4-DCB	52	115
Human non-carcinogenic toxicity	kg 1,4-DCB	1225	3933
Land use	m2a crop eq	300	537
Mineral resource scarcity	kg Cu eq	14	22
Fossil resource scarcity	kg oil eq	3761	11,093
Water consumption	m^3	127	265

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Circular Business Strategies in the Fashion Market: Buying Second-Hand Clothing

Nidhi Arora and Aditi Dhama

Abstract The retail sector in the fashion business has prospered on the idea of fast fashion; however, the trend nowadays is based on 'conserving natural resources'. Apparel manufacturers and retailers all around the world are looking for groundbreaking solutions to lessen the industry's detrimental effect on the environment. These businesses cannot afford to lose environmentally aware customers. Circular fashion is a growing industry that encourages the reuse and recycling of used apparels. Creating a second-hand clothes culture is one of the numerous constants that we may apply to fulfil the concept of sustainable living. As a result, co-consumption and extending the lifespan of garments are the ultimate solutions to sustainability. The environmental activist attaches great importance to the consumption of second-hand clothing through purchasing of second-hand apparels. That is why it is critical to consider the factors that drive the buying of used apparels. These circular fashion techniques serve as a developing business that has resulted in environmental and economic sustainability. This can help even more merchants and customers save money while also reducing the development of significant volumes of fabric waste. The goal of this chapter is to embed new knowledge in the brains of target consumers by understanding the factors that contribute to their decision to buy used clothing. Consumption of pre-owned products would be of interest to marketers, consumers, and socio-environmental activists trying to promote sustainability in the fashion sector.

Keywords Circular fashion · Indian consumer · Second-hand clothing · Sustainability · Sustainable practices

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1 Introduction

The marketing characteristics of fashion include limited predictability, high impulsive buying, a shorter life cycle, and high demand volatility. It is defined as a phrase that has been adopted by a group of individuals over time. More than ever, fashion is characterised by quick changes in style that motivate people to purchase new clothing to feel fashionable. The fast fashion notion, which refers to the idea of cutting lead times and bringing new items to the market as soon as possible, has been a popular industrial trend. Today's clothing is created and consumed at a fast speed since it is designed to be spread, marketed, and consumed in ever-increasing quantities, and it is made to be cheap, simple, and quick to manufacture.

There is no denying that the fashion business has adverse effects (Reichel et al., 2014). Impacts on the environment and on people are closely tied to the industry's ongoing expansion of 'quick fashion' (Rausch & Kopplin, 2021). Fast fashion is a manufacturing technique in which clothing merchants produce a large number of items each year with the intention of selling a large number of items, typically at lower prices (ThredUp, 2020). These businesses want to make the most money possible, even if it means compromising the environment (Rausch & Kopplin, 2021). Fast fashion has transformed consumer behaviour as a result of the casual usage and eventual disposal of goods. On August 22, 2020, the Earth Overshoot Day, which marks the day when humanity has exhausted all of nature's resources for the year, which is evidence that the globe cannot sustain this overconsumption for much longer.

Consumers who are concerned about sustainability in fashion and are calling for change have become more prevalent as a result of understanding of this significant negative influence. However, other researches (Park & Lin, 2020) reveal a gap between consumers' intentions and behaviours, indicating that they still need more involvement and the priority of reality over ideology. In this context, new business models are some of the finest possibilities for the beginnings of the fashion business adopting a more responsible and sustainable strategy. Sustainable manufacturing and consumption are both necessary for sustainable fashion to be achieved. There are numerous effective options to acting sustainably now. New forms of consumption, such as renting, reselling, and grassroots swapping, have been developing to counteract the industry's detrimental environmental effect. More research is required to better understand consumer experiences, motivations, and perceived risk to promote sustainable consumption practises, such as purchasing clothing made of eco-friendly materials and produced under ethical labour standards, upcycling or recycling clothing, or things from thrift shops or sharing economies (Rausch & Kopplin, 2021).

The exercise of buying and selling previously owned clothing dates back centuries, if not millennia. The reusing of outdated clothes while keeping its original usefulness is known as buying second-hand clothing (WRAP, 2013, p. 7). There are long-standing customs of buying used clothing in certain European nations. For instance, in the United Kingdom, buying worn or second-hand clothing is a practise with a strong social foundation (Davis, 2010, p. 270–277). But because of economic

circumstances, particularly the recent economic crisis, individuals from a variety of nations, such as Spain and France, have aggressively entered the used goods market (Guiot & Roux, 2010, p. 356; Williams & Paddock, 2003, p. 318–319). From many research discussed in this chapter, it can be determined that consumer purchasing patterns are changing and that there is an increase in the usage of used apparel. According to a Mintel study from 2002, nearly 40% of UK consumers were actively participating in the second-hand market and over 28% had made a purchase in a charity shop (Williams & Paddock, 2003, p. 320). Similarly, over the past 20 years, sales of used apparel have skyrocketed in France (Guiot & Roux, 2010, p. 356). According to 2013 research by the consulting firm Simple Lógica, the adult population of Spain would engage in the second-hand market at a rate of 50.7% (or 22 million customers) in 2014. Similar to how it is in the USA, buying used clothing is a fairly well-known commercial activity there as well. Examples include flea markets, antique goods, and auctions (Guiot & Roux, 2010, p. 356). In addition, buying used clothing is becoming quite common in India, where the level of life is seen as substandard. Although there are conventional indicators, such as socioeconomic status, that may also be interpreted as barriers preventing some groups of people from buying used apparel. However, as the Internet expanded and, more particularly, as various Internet apps were created and released with new electronic gadgets, customers today have access to incredibly convenient purchasing and selling facilities. The market for used apparel among all socioeconomic strata has also been changed by the usage of social networks and mobile devices. Consequently, more people are buying used clothing every day. It is crucial to consider the variables that come into play when buying used apparel since it is not just a straightforward case of mercantilism. It is a way of life, a means to get the clothes we need and get rid of the ones we no longer find helpful (Damme & Vermoesen, 2009, p. 295). Because of this, it is imperative that more research be done in this field, particularly on how customers purchase used goods and what factors influence their choice to do so. The main aim of this chapter is to discuss the elements that effect second-hand clothing purchases and the strategies used in light of the rapidly growing popularity and commerce of the consumption of second-hand clothing.

1.1 Fashion and Circular Economy

One of the most polluting sectors of the world economy is consistently the fashion sector (Grazzini et al., 2021). The significant environmental damage caused by this industry is primarily the result of its extensive use of water, its heavy reliance on chemical products, and the size of the landfills that are created because of its disposal practises (Fletcher, 2008; Kant, 2012). In addition, environmental factors are not the only things to blame; the fashion industry's negative effects can also be attributed to a variety of other factors. Sustainability is inextricably linked to a moral obligation to one's responsibilities toward those working in the fashion industry on any level. However, new business models in the fashion sector have emerged

in recent years, primarily because of younger generations' search for more affordable and environmentally friendly alternatives. These new business models have been largely driven by the desire of younger generations. For example, buyers appear to take better care of the things they purchase, maintaining them for a longer period of time and ensuring they remain in good condition so that they can later resell them. In addition, consumers should think about the possibility of purchasing previously owned goods rather than brand new products (Herrmann, 2017). Renting clothing, selling second-hand goods, and other cyclical fashion-related new business ventures are all possible in the fashion sector (Shrivastava et al., 2021). It is important to point out that each of these actions contributes to the economic and environmental sustainability over the long term. Yes, this shift is necessary for the planet, and the fashion industry needs to modify its practises and move toward a more circular economy to be successful in the future. The 'grab, make, and dispose of' methodology that is characteristic of linear business models is avoided by circular business models. Linear business models frequently involve misusing and utilising resources in cost-efficient strategies to make money before discarding them as garbage. Circular business models, on the other hand, avoid this methodology. The purpose of circular business models is to extend the product life cycle to reduce the negative externalities experienced by an industry (Patwa et al., 2021).

The feedback loop traditionally used in the fashion industry is intended to be either completely done away with or significantly cut back. The traditional model of business assumes that companies will manufacture clothing, which customers will subsequently buy and throw away. The objective of the circular fashion movement is to produce fewer goods, to promote ethical consumption and purchasing, to reuse and recycle existing materials, and to develop new products using recycled fibres.

In addition, luxury goods are among the items in the fashion industry that are particularly well-suited to be resold or rented because of their superior quality, durability, and classic allure.

1.2 The Pyramid of Basic Needs and Motivations

The buying behaviour of consumer is influenced by personal and emotional impulses as well as motivating habits. As a result, reactions to a certain scenario are particularly influenced by feelings, which ultimately strengthen decisions based on personal goals. Thus, when someone has a need they want to satisfy, they get motivated.

Based on Maslow's sociopsychological theory, the pyramid of needs and motives depicts various requirements at various periods (Maslow, 1970). The demands are arranged according to their significance for a person's fulfilment in a hierarchical sequence. A need becomes a motivation, in accordance with Maslow's Theory of Human Motivation (Maslow, 1970), the moment it elicits a specific want for fulfilment. The needs-based motives vary in the individual's importance and strength (Maslow, 1970). As described by Maslow, Fig. 1 below depicts the pyramid gradually ordering the demands in order of importance.

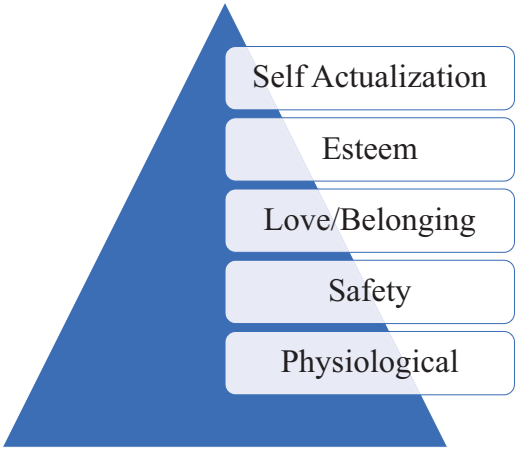

Fig. 1 Basic needs and motivations' pyramid by Maslow

As shown in Fig. 1, five broad categories were set up, ranging from fundamental physiological demands to more complex human needs in terms of cognition and emotion (Maslow, 1970). The two bottom levels are seen as necessities, and as one climbs the pyramid, their significance diminishes. One phase conforms to or completes the other, according to the dynamic-holistic theory, which holds that needs build upon one another. The five phases established by Maslow (1970) are further described below:

Physiological need is the primary factor determining behaviour and consequently, motivation. Inner desires such as hunger or a need for tactile stimulation, as well as the joys of scent and touch, are physiological in nature. Every other necessity seems unimportant to a person who is hungry since their body is yawning for a source of energy.

The second step is the want for safety, which naturally arises out of risk or insecurity in emergency situations. This urge can also be interpreted as an individual's need to safeguard their comfort zone.

The desire to fit in, the first emotional sphere that includes love, friendship, acceptance, and connection, is the third stage. These are all components of achieving a socialising goal since people are social creatures (Dames, 2015). The level of social interaction increases as it approaches esteem, a quality that is desirable in a community of social beings (Dames, 2015).

This urge is a psychological proclivity toward feeling powerful and autonomous when achieving a particular degree of status, which again affects the person's attitude.

The demand for self-actualisation, the top step of the pyramid, is frequently linked to self-realisation and the process of developing a person's individuality. 'The desire to become more and more what one idiosyncratically is, to become everything that one is capable of becoming', as per Maslow (1970). He contends that a need serves as a catalyst and incentive for action as long as it is unmet. However, as soon as a need is partially met, the impetus for taking action disappears

(Maslow, 1970). The hierarchical structure might be viewed critically since it cannot be applied to every person and every circumstance in life. In reality, people react differently although their requirements are at the same level. Similar to how some requirements of one person do not exist for another, so does the degree of difficulty to satisfy a need (Fletcher & Grose, 2012). This study serves as a useful tool for understanding the role of purchasing second-hand clothing as a manner of satisfying needs. However, the fact that people reflect and view things differently is not disregarded. The pyramid also leaves space for dispute from a flexible standpoint since interconnected phases inside their borders still seem fluid and overlapping (Maslow, 1970).

1.3 Overconsumption

The availability of natural resources, such as raw materials, clean water, electricity, and agricultural land, is essential to our way of life. Despite this, the rapidly expanding consumption of humankind has resulted in significant negative effects. Our supplies are rapidly dwindling and will soon be exhausted. The prevailing weather patterns on Earth are currently undergoing a transition toward a more unfavourable state. There is an urgent need to make significant changes to the way of living so that life continue to exist on this planet in a far more environmentally friendly manner. The majority of the environmental issues can be traced back to the consumption and use of materials. This is because the intake of materials ultimately results in the output of trash.

It is a fact that over use of resources has negative effects on both the environment and society on a global scale. The developing difficulties are particularly severe in the less developed nations of Africa, Latin America, and Asia. Even if the process of resource extraction is not evenly divided around the world, developing nations often have more natural resources available (although not always). The exploitation of resources, as well as the usage of water and land, are all implicated in major environmental issues, such as the degradation of arable land, water shortages, toxic contamination, and so on. Goods need to be moved to facilitate international trade. The emission of greenhouse gases is increased by transportation.

In comparison to a few decades before, people today extract and utilise a far greater quantity of resources. Utilisation of resources and consumption of goods are not occurring at the same rate in every part of the world; rather, these processes move more quickly in certain parts of the world than in others. Because people living in wealthy countries consume up to ten times as much as those living in underdeveloped countries, it stands to reason that they require significantly more resource units. As a direct consequence of this, the environmental backpacks of wealthy countries are significantly larger than those of underdeveloped countries. Europe has the largest net imports of resources thanks to its high population density (approximately three tonnes per capita per year).

Regarding the outlook for the future, it is anticipated that worldwide extraction, production, and consumption would all increase. This expansion will be driven in large part by rising consumer spending in developing nations. These nations have a justifiable desire to enjoy a lifestyle that is comparable to that found in more established areas around the world, and also the population of these countries is expanding quickly. The number of people living on Earth currently exceeds what the planet is capable of supporting. Many non-renewable resources will reach their maximum level of exploitation, and even the fewer ecosystems will be left that can still supply us with biological resources. The environment is limited to a certain quantity of waste materials at one time. In today's world, significantly more research programmes are being used so that the global ecosystems are able to give in a way that is sustainable.

1.4 Second-Hand Clothing Consumption

In previous studies, the topic of second-hand clothing has been examined from a variety of perspectives. Research has been conducted on the trade in used clothes and how the pre-industrial, industrial, and post-industrial eras affected it over time in Europe (Ginsburg, 1980; Frick, 2005; Damme & Vermoesen, 2009; Barahona & Sánchez, 2012). This research provides a historical perspective on the topic. The concept of selling previously worn clothing is also central to the retail trade industry. In spite of the fact that it has been done for centuries, the practise of selling previously owned clothing has recently gained popularity in India. Alongside the growing popularity of vintage clothing, the topic of fast fashion has emerged as a subject of study. This is largely attributable to the growing backlash against the industry as a whole, as well as the enormous amount of textile waste that is produced as a result of the short garment lifespans are the result of many customers' propensity to be wasteful (Ferraro, 2016). Thus, the retailing of used goods has recently been incorporated into the larger supply chain management framework and developed into the centre of reverse logistics. Reverse logistics focuses on the flow of material that occurs after the use-phase of an item (Kant-Hvass, 2014). In addition to disposal, which is regarded as the option least preferable in terms of the environmental sustainability of a choice, reverse logistics considers every possible way to return material flows. Recycling, and especially reusing clothing, are the superior forms of waste management. The market for pre-owned clothing and accessories has grown in importance as a distinct type of alternative consumption channel in the field of environmental sustainability (Guiot & Roux, 2010).

1.5 The Market for Pre-Owned Products

Researchers have been intrigued by the meteoric rise of the market for used clothing over the past 20 years, which has prompted them to ponder the question of why individuals choose to purchase previously owned garments (Guiot & Roux, 2010, p. 355). Used clothing is gaining popularity as an alternative to new clothing among consumers for a variety of reasons, including those related to the economy and the environment (Guiot & Roux, 2010, p. 356). According to Williams and Paddock's research, the majority of people who shop at online second-hand retailers are members of economically disadvantaged communities that are unable to afford new clothing from traditional forms of retail distribution (2003, p. 318). Despite the fact that the majority of people who purchase used clothing come from economically disadvantaged groups and make up the majority of the second-hand market, some people assert that even economically reasonable customers engage in the second-hand market (Williams and Paddock, 2003, p. 319). In this context, the term 'rational consumer' refers to an individual who seeks to maximise their own utility to receive the most desirable rewards (Shugan, 2006, p. 1).

According to Guiot and Roux (2010, p. 356), members of the middle class are seeing a decline in purchasing power because of the recent economic crisis and are increasingly participating in the market for previously owned goods. Because of this consequence, they are buying more clothing that has been previously worn. Even more so, the assumption that the only people who participate in the secondary market are those from lower- and middle-class socioeconomic backgrounds is completely flawed. An investigation conducted by Scitovsky (1994, pp. 36–42) demonstrated that members of the upper class are also active participants in the second-hand market and that individuals from all economic strata make use of the second-hand market. Additionally, when we view it from a different perspective, we can see that the used market not only enables business between the manufacturer and the customer (also known as M2C business), but also business between the customer and the customer (also known as C2C business). In 1987, for instance, AT&T and IBM began marketing their used network equipment. It is possible only because of availability of the Internet for anyone to quickly and easily access websites that host online flea markets. Because of the Internet and the development of new mobile and intelligent devices, customers now purchase clothing in different ways. This issue needs to be considered because the second-hand market is not an exception to this rule. Therefore, it is essential to understand the factors that influence the choices that customers make when they are shopping for used clothing. This is because a manager is in a better position to devise an efficient marketing strategy when they have an improved understanding of the relevant influencing factors.

2 Reasons for Shopping Second-Hand Clothing

In former times, purchasing clothing that had been previously owned was understood to be an indication of financial hardship. Since the 1990s, there has been a significant shift in attitude toward the practice of wearing previously owned clothing. In the 1990s, 'retro fashion' gained popularity as a means of reliving the decade of the 1970s. These days, it is considered hip to dress in vintage garb. The importance of environmental concerns has recently come to the forefront of consumers' minds as they have begun to comprehend the value of previously owned clothing.

1. The economic circumstances of some people necessitate the purchase of previously owned articles of apparel. The habit of reusing previously owned garments as a method of cost reduction has a long history. In some societies, clothing that has been worn previously is almost the only source of 'clothes that is modern in way'. A conflict-avoidance tactic and an alternative path due to the stress of poverty, purchasing second-hand clothing is an option for consumers with limited financial resources. Because of this, purchasing previously owned garments might result in significant financial savings. On the one hand, to meet financial obligations, one purchase used clothing. The urge to pay the lowest possible price while yet receiving satisfactory value is innate to humans. It feels a sense of accomplishment when an individual successfully negotiates a lower price. When it comes to purchasing respectable used clothing, this is one of the most important motivating factors. Consumers who are concerned about their financial situations are often motivated to purchase previously owned items because of the price differential between second-hand clothing and brand new products.
2. It should be noted that the motive of second-hand consumers is not always restricted to monetary considerations. Additionally, ethical consumerism plays a role in this. The load that the fashion business places on the environment is lightened thanks to the proliferation of the second-hand clothing trade, as also previously stated. There is a fresh movement toward more environmentally accountable behaviour on the part of consumers. Consumption of previously worn clothing might also be motivated by an ethical sense of responsibility. It is possible that one can be more careful with the disposal processes. Donating, recycling, reselling, and reusing our pieces are all purposeful decisions in sustainable fashion. The reuse of textiles has significant positive effects on the environment. Overall, this is a more environmentally responsible approach to the use of clothing because it allows for product reuse, reduces the consumption of natural resources, and stops waste from building up.
3. The specific qualities of second-hand clothing stores set them apart from other distribution methods; consequently, making purchases at these establishments leads to a higher level of social contact and behaviour that encourages customers to browse more (Guiot & Roux, 2010 in Han, 2013). The sentimental value is something that is strongly associated with vintage clothing. The term 'nostalgic feeling' refers to a craving for the past and a desire to return to happier times.

The occurrence of this phenomena is one of the primary motivating forces behind the existence of second-hand stores.

4. As was stated before, one of the ways that people exhibit themselves is by the attire they wear. They are able to find items that have a unique worth and an allure of product scarcity in the thrift stores that we frequent. People crave for products that are one of a kind, extraordinary, differentiated, and special in some other way. The following kinds of establishments are ideal for fulfilling requirements of this nature: antique stores, vintage stores, swap meets, flea markets, and so on (Han, 2013).
5. Going to thrift shops and buying used things is a form of entertainment and a form of pleasure. Additionally, we get to experience the joys of window shopping and breaking away from our normal routines. This makes people spend some of their free time pursuing thrift stores and antique shops.

2.1 Motivational Dimensions for Second-Hand Clothing Consumption

For as long as there have been poor people in the world, people have had to resort to buying used clothing. This practise dates back to at least the Renaissance (Frick, 2005). Many different periods of history have left traces of second-hand consumption, illuminating its growing importance right up to the current day. Before the industrial revolution, only the wealthy could afford to buy brand new garments. Thrifting and the widespread trading of pre-owned clothing helped make new garments available to people of all socioeconomic backgrounds (Frick, 2005). A larger second-hand clothing market developed during the Industrial Revolution, about 1700–1850 (Lambert, 2004; Sanderson, 1997). Its low prices drew customers in and helped propel the establishment of a sizable commercial infrastructure.

During the early stages of the industrial revolution, second-hand clothing was not as widely accepted as it is today. In between of the nineteenth century, ready-made clothing became more readily available and affordable, leading to a drop in the second-hand trade (thanks to the invention of the spinning wheel). Therefore, low-income families were associated with the stigmatised practise of wearing previously owned apparel (Ginsburg, 1980). It is speculated that this is how second-hand clothing got its bad name. Recycled clothing did not become popular with the general public in Europe until the 1990s, when 1970s-inspired styles were brought back (DeLong et al., 2005). As it has become trendier to dress in period garb, this has gained in popularity (McColl et al., 2013). Rising consumer and business interest in sustainability has also led to a greater focus on the connection between buying used clothes and being environmentally responsible (Ferraro, 2016). With the upsurge in popularity of used clothing, numerous researches have been performed to investigate the many motivations behind this trend beyond just economics.

The past two decades have seen an n-number of studies conducted on the topic of second-hand clothing use. DeLong et al. (2005) particularly examine the vintage context. Additionally, it has been investigated in relation to luxury, for example by Turunen and Leipämaa-Leskinen (2015). Western societies have not been the only ones to examine the second-hand clothing industry; researchers in Asia, such as Chan et al. and Xu et al. (2014), have also contributed to this field (2015). Some studies (Williams, 2003; Bardhi & Arnould, 2005; Guiot & Roux, 2010) focus on the broader context of pre-owned clothing, while others (Cervellon et al., 2012; Guiot & Roux, 2010) narrow in on clothing alone. The significance of the latter to the overarching purpose of this investigation is elaborated upon in greater detail below.

As the usage of second-hand garments in Western culture extends beyond mere practicality, studies on the factors that drive this trend have been conducted across a range of contexts. New studies have begun to hint at this phenomenon in terms of recreational and economic benefits (Bardhi & Arnould, 2005; Guiot & Roux, 2010). The authors of this article, Ferraro (2016, p. 263), claim that satisfaction and gratification are the primary driving forces behind second-hand consumption. Scholars in the field of second-hand purchasing have examined several types of consumer motives, both within and between different consumer groups. For instance, Williams (2003) investigated the motivations behind patronage of non-traditional retail settings such as thrift stores. The findings indicate that consumers' motivations for purchasing pre-owned clothing are affected by their economic circumstances and levels of disposable money. The low purchasing power of this demographic group is the primary motivator for their use of non-traditional retail channels. Those with more disposable wealth, on the other hand, can choose to satisfy their 'want for enjoyment, sociality, distinction, show, the spectacular, the deal and being perceived to buy the correct things' (Williams 2003, p. 237). Williams (2003) also makes reference to earlier research in this chapter that looked at how individuals purchase used clothes to give it a personal significance. Younger women from higher-income households were the ones who stood out as doing this the most. The study made a start by identifying several motivating factors for second-hand purchasing, which were often influenced by the economy (Williams, 2003). Further research has looked at the presence of hedonic (recreational) as well as utilitarian (economic) incentives.

By 'defining thrifting as a temporary situation where both the economic and hedonic orientations exist and analyse the function of thrift in conjunction with treat', Bardhi and Arnould (2005) take a dialectical look at second-hand purchasing in thrift stores. By doing so, the premise of Miller's (1998) 'Theory of Shopping', which assumed that frugality and danger cannot coexist, is called into doubt. Additionally, it is proved that both the recreational and economic aspects coexist. Guiot and Roux (2010) expand on these and add a crucial component that takes into account ecological and moral considerations. Through this method, they were able to identify the tripartite structure of second-hand customers' motives and create a scale for measuring these motivations that can be used on many garment categories without regard to a specific distribution channel (Guiot). The foundation for

additional research has been laid by the researchers' major contribution to current scientific research on the causes of second-hand consumption.

Further research specialised in apparel in a fashion-related setting as Guiot and Roux (2010) did not concentrate on a certain line of used clothing. The motivating factor of fashion is added by Ferraro (2016) with respect to the three aspects of Guiot and Roux (2010), demonstrating how important fashion is nowadays when buying used items.

Despite the fact that Guiot and Roux (2010) and Ferraro (2016) provide several interconnected reasons that influence second-hand shopping, they have only focused on one factor that stands out. The recreational, economic, critical, and fashion spheres all exhibit the four motivating components, which will be further examined in the theoretical framework.

Also focused on apparel, Cervellon et al. (2012) explore reasons why ladies choose vintage clothing over second-hand. One study specifically examines the role that eco-awareness plays in the decision to buy used clothing, even if this has not been proven to be a driving factor. College students' buying habits of used clothing were analysed by Yan (2015) based on various psychographic factors, including environmentalism. They compared the differences between those who buy used clothes and those who do not, taking into account people's attitudes toward environmentalism and their perceptions of how sustainable used clothing is. However, assuming that buying used apparel is not a reflection of their mentality, that has not affected how frequently they visit consignment stores (Yan, 2015). Also, compared to those who do not shop, college students who buy goods from consignment shops typically have a higher level of environmental consciousness.

2.2 Second-Hand Clothing Sales Stores

- *Second-hand shops*: In addition to vintage and specialty stores, other second-hand stores and markets include consignment shops, thrift and charity stores, online auction sites, flea markets, antique shows, swap meetups, garage sales, car-boot sales, and classified ads. Independent, unstructured, and tertiary markets are the terms used to describe them respectively (Hansen, 2000; Mhango & Niehm, 2005 in Han, 2013). The retailing forms of the aforementioned stores are distinct from those of conventional ones; consequently, it should come as no surprise that their marketing approaches and business strategies (if any exist!) are also distinctive from those of conventional stores.
- *Vintage stores and boutiques*: Used clothing can be traded for something new in a conventional manner at establishments such as thrift shops and boutiques that specialise in vintage goods. Retailers select a number of different items from the suitable extensive product range, but they are unable to provide product depth or sizes that are specifically tailored to individual needs. The chapter discusses about the buying and selling of vintage items, which are things that have a long

history and are difficult to find. Customers feel a stronger emotional connection to the items because of their inherent value (Han, 2013).

- *Consignment shops*: Things in good condition are often only accepted at consignment stores; these items must be free of stains, rips, mothball or smoke odour, animal hairs, missing buttons, and broken zippers. In addition, mothball or smoke odour should not be present. Additionally, the items must be seasonal and relatively recent (between 1 and 2 years old). If an item has not been sold within a certain amount of time, it is given back to the person who originally owned it (Han, 2013).
- *Thrift stores and charity shops*: They are essential to the preservation of the environment from an ecological standpoint because they prevent used clothing from being dumped in landfills and provide people with lower incomes with access to reduced-price shopping (Weil, 1999 in Han, 2013). Donations can be made to thrift stores by individuals as well as institutions that focus on charitable giving. The business model of thrift stores can be broken down into three distinct classifications: for-profit, linked with charities, and non-profit. Thrift stores are run by non-profit organisations, and a portion of the profits from the sales of used clothing that has been donated are given to charitable organisations either directly or indirectly. The proceeds from the sale of items at thrift stores that are run for profit but are affiliated with charitable organisations are used to support the day-to-day operations of non-profit organisations. Thrift stores that are run for profit buy merchandise from individual vendors or from wholesalers, and then resell it to make a profit. Naturally, the different kinds of computer operating systems have an impact on the store's atmosphere, its selection of products, and its layout (Han, 2013). Up until this point, we have only included charity thrift stores that are officially recognised and have physical locations. On the other hand, there are unplanned flea markets, fairs, auctions, and expositions, which are examples of non-store businesses and transactions that are not formal in nature.
- *Swap meets and flea markets:* These are two examples of venues that facilitate the exchange of goods between buyers and sellers. Not being low-class consumers is not the primary reason that people shop at swap meets and flea markets; rather, they go there in search of deals and hidden treasures (Han, 2013).
- *Car boot:* A setting where used goods can be bought and sold is where car-boot sales take place.
- *Online auction:* Services such as eBay and OLX exist virtually rather than on the ground, and anyone can join the service and participate in transactions as either a buyer or a seller. People are able to sell their own belongings at a price that is agreeable to both parties, which has been arbitrarily determined here. In this particular scenario, we are going to be talking about turning a disposal into a stock.

3 Factors that Influence the Customer's Purchase Decision

A customer is a person or company who buys clothing for their own use or the use of others. The acts that consumers conduct when they select, obtain, utilise, or discard the goods or services are referred to as customer behaviour. When a customer decides to buy clothing, he goes through a number of stages of the process, including problem recognition (where the customer feels like he is missing something), information search (learning more about the clothing), evaluation (evaluating alternatives), purchase (buying the clothing taking all the factors into consideration), and feedback. According to prior research, there are two key influences on a customer's purchasing decisions: environmental variables (such as culture, the reference group, social class, family, and household) and human aspects (such as demographics, consumer perception, knowledge, inspiration, learning, personality, attitude, thoughts, and lifestyles) (Sata, 2013). Other elements that customers consider while purchasing apparel include pricing, product attributes, the market, societal attitudes, and location. Comparatively, such consideration variables vary depending on the type of apparel and the buyer. For instance, when buyers pick an automotive brand, quality and pricing are the two most crucial considerations (Jean, 2004). Price and features for delicate electrical items such as mobile phones become crucial considerations for the consumer (Sata, 2013). Even for the buyer, it is not always easy to select a piece of clothing from a comparable fashion category. For instance, a customer might need to buy a jacket. He has a variety of possibilities in the marketplaces on where to get the jacket. Thus, while picking their apparel, buyers may benefit from aspects including product attributes, brand, price, societal attitudes, location, and others. Even the aforementioned elements are closely related to one another. For instance, the brand image of apparel has an impact on how people perceive it (Huang et al., 2004); the price also affects brand perception (Jacoby et al., 1971); and experience has a significant impact on the market (Huang et al., 2004). The value of brand, price, cultural attitudes, and location in relation to second-hand clothing will be the focus of this essay.

Depending on the product type, a client may behave differently. It indicates that the author thinks customers behave differently depending on the product category and that various product kinds have varied purchasing habits. Even prior research concurs with the author's assertion that consumers' purchasing habits vary depending on the type of goods. For instance, when consumers choose to purchase an expensive item such as a vehicle, quality and pricing are the two most crucial considerations (Jean, 2004, p. 22). Price and features for delicate electrical or technology items such as computers and mobile phones become essential factors for the buyer (Sata, 2013, p. 103). Even if choosing a product from a similar product category is not always easy for the customer, there are instances when the consumer must consider other aspects before making a final decision, such as price, brand, quality, and others. For instance, a client needs to purchase a laptop. He has a variety of possibilities in the marketplaces on where to get the laptop. Brand is expected to have a big influence on consumers when they are thinking about buying a product

because it has a trust value for customers and also displays the standard of trusted products (Louis & Lombart, 2010, p. 129). Customers might perhaps decrease the risk linked with the product's quality, damage, or other reasons by using this brand image. Additionally, the effect of product purchase channels, such as online and offline, must be considered. Even earlier research makes the case that there is a connection between product quality and various selling channels. Examples include 'varying quality products linked with varied channel architectures'. In accordance with the product's purchasing channel, the manufacturer or supplier also determines the product's price. Therefore, the author of the current study can claim that a number of product factors, including price, brand name, channel, and risk, have an association with the product quality, that the latter influences the consumer's decision to buy a product significantly, and that the latter is subject to a number of risks associated with the product quality (Garvin, 1984, p. 25). Product quality risk is described as 'the risk of a product (for example, health, financial, safety risk, etc.) given to customers and created by its inherent quality problems (for example, in raw materials, ingredients, production, transportation, or packaging)', according to. However, this product quality relies on how each consumer perceives the quality, since some consumers may place more value on product performance, dependability, and durability, as well as some consumers may place more value on perceived quality (Garvin, 1984, p. 27). According to Garvin (1984, p. 29–30), the fundamental elements of product quality fall into eight categories: performance, features, dependability, compliance, durability, usability, aesthetics, and perceived quality.

Five influencing elements that can have an impact on a customer's decision to buy used clothing were considered in this chapter (as shown in Fig. 2). It is thought that a customer's choices while buying used clothing are influenced by a variety of factors, including product attributes, price sensitivity, market risk, emotions and experience, location, and societal attitudes. Comparatively, these elements also affect one another.

3.1 Brand Attributes

To begin, a brand helps a retailer set their products apart from the competition in the clothes market (Louis & Lombart, 2010, p. 129). In a similar vein, people select a brand that accurately represents their own personality. King argues that his brands succeed not only because of his or her skills and appearance, but also because consumers genuinely like them (1970, cited in Azoulay & Kapferer, 2003, p. 144). The shopper is encouraged to put their faith in a product because of the brand, as indicated by this remark. When customers have faith in a company's reliability, they are more likely to make purchases of higher quality clothing. King (1970, cited in Azoulay & Kapferer, 2003, p. 144) compares the importance of a brand while choosing between several items of clothing that are similar to the comfort a trustworthy friend may bring due to the mutual respect established between them (Louis & Lombart, 2010, 129).

Fig. 2 Factors influencing decision to purchase

Brand attributes are a staple topic in the literature on marketing and consumer behaviour. It has been shown through previous research that brands, like people, have distinct personalities (Aaker, 1997). Given the significance of brand and its impact on consumer behaviour, a great deal of study has been done on the subject of brands during the past 20 years from a variety of angles. Attempts have been made by researchers to look at the brand problem from all directions. Many researchers have focused on the following aspects of brands: 'brand overall fit; brand type; brand knowledge; explanatory links; parent-brand memory structures; level of concordance; relatedness of the divisions; sub branding; brand name suggestiveness; band width; brand specific affiliations; brand extension typicality; brand extensions that intervene; positive affect; and brand attitude'. Today, a garment's brand name serves as a proxy for the garment's quality, which is a feature of increasing importance. Marketers are finding it harder to establish a distinct identity for their product in the face of increased competition. The cultural fear of being imitated by a competitor has made it more difficult to introduce novel aspects into established clothing lines. Despite the current financial climate, this truth shines through. With all of that in mind, it is clear why establishing a strong brand identity for a clothing line is challenging and important for both the marketer and the consumer. When shopping for clothing, consumers often feel overwhelmed by the abundance of options available, since many items appear to be identical. Consumers who are unsure of what to purchase often weigh numerous elements, including cost, value, and brand familiarity (Aaker, 1997, p. 347). Looking at branding's worth from the customer's perspective, it becomes clear that the brand's power greatly influences purchasing decisions (Louis & Lombart, 2010, p. 129). The consumer's mind may form an association between a particular word or symbol and a certain good or service. Examples include the slogan 'Just Do It' and the distinctive swoosh design used by Nike. In addition to conjuring an image, brands stand for abstract concepts things as trust and caring in consumers' perceptions. Customers are more likely to make purchases from these companies because of the personal connections they have formed with their brands. Brand awareness helps the clothing stand out from the crowd of similar products on the market (Aaker, 1997, p. 347). To attract customers, a company must cultivate a favourable perception of its brand. Previous research has found that consumers are more likely to buy items of apparel that evoke favourable emotions and thoughts. It is the marketer's responsibility to implant this symbolic image in consumers' thoughts to encourage self-expression through clothing (Keller, 1993, p. 4).

It is unclear, however, how brand power functions when it comes to the consumer's use of pre-owned clothing. In this chapter, we will look at how buyers evaluate the quality of a used clothing brand.

3.2 Product Price

Second, the price is a major consideration for shoppers when they are looking to buy new garments (Chang & Wildt, 1994, p. 16–17). It is also seen helpful for the client knowledge (Jacoby et al., 1971, p. 570). The term 'price' refers to the monetary consideration that a customer must give to a vendor to acquire the legal title to some article of clothing (Wu et al., 2011, p. 290). Campbell (1999, p. 145) found that price 'may represent more to consumers than just a financial exchange of value', and this might have a significant impact on how a customer behaves. For instance, if the clothing item has a high price tag, the buyer may do some further research before making a purchase decision (Wu et al., 2011, p. 290). Most consumers value high-quality products and services, however, they are not prepared to spend more for them (Qian, 2011, p. 505). Additionally, a high price reduces the likelihood that an item of clothing will be sold (Völckner & Sattler, 2005). The final pricing of a customer's clothing item is determined by the manufacturer, marketing manager, or retailer based on a number of factors, including the item's cost, potential profit, and other factors; these individuals rarely, if ever, consult with the consumers themselves (Campbell, 1999, p. 145).

The shopper must pay for the full retail price of every article of apparel purchased. Clients part with their cash in exchange for the benefits offered by the services or products being sold. It is important for consumers to keep this in mind when choosing a store, brand, and clothing to buy clothes, especially 'often purchased things' (Diaz & Cataluña, 2011, p. 371). According to Diaz & Cataluna, price is not a deciding factor in all markets and industries, but it has a considerable role in the sale of commonly purchased clothing (2011, p. 371). Producing costs plus a predetermined percentage for profit equals price. The company's marketing director once explained that 'the price is what the customer is willing to pay for the value of the bundle of qualities that is being supplied, and is what generates the resources that support all of the other activities of the organisation' (Campbell, 1999, p. 145). The price represents what the consumer 'must give up in order to acquire the value of the bundle of attributes in the clothes offering' (Campbell, 1999, p. 145). Price may be interpreted as a financial burden, and greater prices may have a negative effect on the likelihood of a purchase (Völckner & Sattler, 2005). Buyers will take more time to consider their options when the price of clothing is high (Wu et al., 2011, p. 290). Price is seen by some as an indicator of quality in clothing, as stated by Huang and Sarigöllü (2012, p. 54). Similarly, Chang and Wildt (1994, pp. 16–17) note that the price of an item of clothing is considered as a measure of its perceived quality, which influences the consumer's intent to buy.

After surveying the relevant research, this chapter explains why apparel pricing is so crucial to both retailers and shoppers (Campbell, 1999, p. 145). All prior price-related studies have centred on the need for fresh clothing. Yet, previous studies neglected to highlight the importance of cost when considering second-hand apparel. Once this distinction is made clear, the chapter will explore how consumers evaluate the value of pricing when purchasing used goods. Therefore, this chapter's goal is to examine how price influences consumers' decisions to buy used apparel.

3.3 Societal Perceptions

There has been little study done on the link between Indian consumers' environmental knowledge and attitudes. According to research, Indians are growing more knowledgeable of excessive fashion waste, water pollution, and air pollution (Armstrong et al., 2015).

While some studies indicate that customers are reluctant to make sustainable purchases due to a lack of knowledge. Particularly in relation to second-hand consumption, it is critical to gauge Indian consumers' familiarity with the environmental implications of rapid fashion and the lack of new clothing production. The likelihood of a positive customer attitude increases with knowledge level.

Indian consumers' purchase decisions are significantly impacted by social factors. Reference groups, social networks, and even the media are included. Indian customers' decisions to buy used clothing are heavily influenced by what other people think and by what Indian culture views as rude or forbidden. The majority of Indians think it is offensive to admit that they dress in old clothing because they think doing so is a sign of poverty and low socioeconomic position. They also consider that buying and wearing used clothing is a sign of poverty It is also depending on the class to which a person belongs. In the lower and lower-middle classes, luxury and branded apparel are not highly desired, therefore individuals consume used goods more frequently. However, in the upper middle and upper class, one's appearance is scrutinised and seen as a reflection of their position, so using used products is a source of shame.

3.4 Market Place

The marketplace or location is where the goods or services being sold are physically available for purchase by the end user. It is a crucial element of what marketers call the 'marketing mix' (Kotler et al., 2005, p. 857). The term 'distribution channel' is another name for this phenomenon. This chapter's analysis by the author where this distribution model finally results in. A distribution channel's last stop could be a physical store or an online marketplace. Despite the fact that 'the benefit from the use of something is equal whether the customer purchased it at a retail

establishment or on the Web', the industry or site still has a considerable influence on the purchasing decisions made by customers (Bhatnagar et al., 2000, pp. 98–99). When a customer wishes to make an online purchase, for instance, she may experience more peer pressure because she is not physically adjacent to the product (Bhatnagar et al., 2000, p. 98). On top of that, 'online customers may anticipate more clothing data, a bigger range of apparel, and more customised or specialised apparel' than they would get from more conventional means of purchasing clothing. Furthermore, in contrast to in-store customers, Internet buyers are not as motivated to make purchases for the sake of entertainment or fun.

Consumers can shop for clothing at a wide selection of stores without ever leaving the comfort of their own homes, and without having to travel to any large store locations (Bhatnagar et al., 2000, pp. 98–99). Saving gas and time, customers may now buy clothing from online retailers rather than visiting a brick-and-mortar shop or traditional market (Bhatnagar et al., 2000, p. 98–99). Customers can now save time and money by conducting thorough research before committing to a purchase from a single online business, rather of bouncing between several (for example, between competing vendors). The result is a less complicated interaction with the company for the customer (Wu et al., 2011, p. 290).

Researchers have found that shoppers' reactions to prices vary greatly depending on whether they are making their purchase in a physical or virtual store (Zhou et al., 2007, p. 48). People often shop online because they want to get the greatest price possible, for instance (Zhou et al., 2007, p. 48). Numerous studies have been conducted recently to determine the elements that affect consumers' preferences and actions when shopping, both in-store and online. The vast majority of studies, however, have zeroed in on online shopping, the buying process, the issue of trust and societal views, and the impact that trust and societal views have on consumers' decision-making. Therefore, studying the impact of seller location in the second-hand market is essential.

3.5 Risk

Perceived risks are threating that consumer think they will face if they make a purchase. Furthermore, there is a distinction between markets (such as online and offline) with regards to both the frequency and kind of perceived dangers. When making an online purchase, a customer may worry about a number of factors, such as the security of their financial information (e.g. is the product quality is same as described over website?), the timeliness of their delivery, the reliability of their purchase (e.g. is the product quality as described?), and the ease of their ordering and return processes. There are a variety of risk management strategies that companies use to protect their clients and reduce potential impact while also considering their concerns. A company's usage of risk management strategies will never be enough to eliminate all danger. Buyers face a number of risks during the purchasing process, as detailed in the literature on product risk. The literature also mentions the

amount and type of risk as factors influencing consumers' purchasing behaviour and decisions. Financial, psychological, performance, physical, and social hazards are the five categories of perceived risks that have been identified by prior research as being connected to a product. So, to lessen the danger of buying the product, a customer makes use of several precautions. Some shoppers hedge their bets by looking into the store's history or the product's guarantee, while others rely on recommendations from friends or online reviews. Additional risk-reducers that a customer might think about are things such as refund policies, brand loyalty, and reputable retailers. Previous research has indicated that while there are greater psychological risks associated with purchasing clothes products than with purchasing food, autos, or televisions, there are still substantial financial risks associated with making these purchases. The dissimilarity in the level of risk association is also impacted by the mode of purchase. Customers who choose to shop in a brick-and-mortar store rather than online are taking a safer option. Acc. to the research customers 'cannot experience any sensation associated to the things they investigate on the Internet (seeing, touching, tasting, smelling, and hearing)', which is a major drawback to online purchasing. When comparing the shopping experiences of online and brick-and-mortar stores, customers place a larger value on the security of the latter.

Previous studies have demonstrated that the riskiness of the situation online correlates positively with the likelihood of engaging in risky behaviour. Despite being a relatively recent development, online shopping that people are slowly becoming more acclimated to, buying used is still seen as a riskier decision due to the lack of assurances and warranties. It could also be that the buyer of a used item is underestimating the wear and tear that the product has endured. Customers must have faith that the seller is providing truthful descriptions of the pre-owned items they are purchasing. The chapter delves into the worries people have about brand new things, but it notes that researchers have not traditionally focused on the dangers of previously used goods. In this section, the author provides an assessment of the dangers associated with buying previously owned items.

3.6 Emotions and Experience

Consumer perceptions about goods and experiences may be significantly impacted by emotions. A broad affectivity is a result of emotional events, which frequently produce either good or negative sensations and a certain degree of enjoyment or discomfort. Second-hand apparel buying has been described as a deeply intimate activity that evokes memories. According to some authors, this nostalgic sensation is brought on by a reminiscence of the past while there are some negative perceptions about the current. Others demand some connection to a specific stimulus (such an item, a smell, etc.) that might elicit an emotional reaction. Although Holbrook and Schindler argued in 1991 that nostalgia is a time-based preference that is strongly rooted in one's emotional past experiences, it has since gained more attention. In these articles, shoppers looking for used clothing could have a nostalgic

feeling while browsing vintage apparel, made about by oneself memories of previous trends.

The relationship between a customer's purchase experience and their emotions, both good and negative, appears to have a significant impact on how they will behave today and, in the future, when buying used items. Recalling the aroma, atmosphere, colours, and fashions may bring back childhood memories and elicit strong reactions that may influence a consumer's desire for buying used apparel. Furthermore, it has been demonstrated that persons who have a desire to buy used clothing typically have linkages with memories of earlier events, elicited either through tangible or irrational stimuli.

4 Four Sustainable Brands That Adopted Second-Hand Clothing: Case Studies

Source: thegoodtrade.com (2021)

4.1 Patagonia Worn Wear

Website: https://wornwear.patagonia.com/
Located in: State of California
Ideal for: Sweaters, parkas, and other outerwear items
Ethics: Ethical considerations include certification as a B Corporation, fair labour and working conditions, eco-friendly materials, closed-loop waste management, charitable donations, and upcycled product options

With its Worn Wear initiative, Patagonia, which has been an environmental activist for many years, demonstrates that it remains true to its roots despite becoming a certified B Corporation. After being gathered from Patagonia's distribution hubs and used products from its customers, clothing is put through a closed-loop process that does not involve the use of any water. This ensures that new products are especially clean and does not result in any waste being produced. Worn Wear is a retailer that offers a wide variety of products, including clothing for adults, clothing for children, packs, gear, and even items that have been upcycled from discarded or unwanted materials.

4.2 The Hackwith Design House (Hackwith), The Sustain Shop

Website: https://hackwithdesignhouse.com/the-sustain-shop/

Based in: Minnesota
Ideal for: Dresses and wraps are what this fabric is most suited for
Ethics: Made in the USA in an ethical manner; made-to-order; locally sourced and environmentally friendly materials; upcycled product options

Since everything in the Sustain Shop at Hackwith Design House is made-to-order, the store is happy to accept lightly used or returned clothing to clean and resell it. If those old components need significant repairs, the team will collaborate with the local sewers to upcycle them and remake them into new components. Because sizing information and image descriptions are included with the product listings for all Sustain items, it will give a good idea of how they will fit before purchase. Dresses, wraps, and other lightweight outerwears are some of its classy items available at the brand.

4.3 Tradlands

Website: https://tradlands.com/
Headquarters: Washington
Ideal for: The great outdoors, suitable for the entire family
Ethics: Carbon-neutral, member-owned co-op, ethical and responsible production, and giving back to the community

By providing thousands of items in almost brand new condition, REI Good & Used makes its extensive collection of clothing and equipment much more accessible to customers. Clothing can be purchased for as little as $6, with an emphasis placed on circular production, accessibility, and waste-free procedures. Given how expensive outdoor gear can be, one of the things that we appreciate the most is that one can purchase anything from hiking boots to sleeping bags without completely emptying bank account. REI sales are always reinvested in the co-op, so that everyone can benefit equally from the co-commitment ops to sustainability.

4.4 Levi's Second-Hand

Website: https://www.secondhand.levi.com/
Based in: California
Best for: Denim jeans & jackets
Ethics: Ethical considerations include the use of recyclable and environmentally friendly materials, production in an ethical manner, and a repair and redesign programme

Levi's Second-Hand is the online second-hand store that people turn to when they are looking for that classic denim they all love. On the second-hand market,

one can find a wide variety of adult clothing items, including jackets and jeans in vintage-inspired styles, which have already been worn in and are prepared for use. Because the size of denim has evolved over time, Levi's provides with a helpful guide to assist in discovering one's ideal fit.

5 Findings

1. *Price*: Price acts to be the primary factor affecting buyers when buying second-hand goods. Additionally, the research previously evaluated provided evidence that consumers buy used goods for practical and financial aspects (Guiot & Roux, 2010, p. 356; Williams & Paddock, 2003, p. 319). Therefore, it was expected that customers would prioritise cost from a rational and economic standpoint as a decision-influencing element when purchasing used goods. This is due to the strong theoretical link between pricing and rational and economic behaviour.
2. *Product risk*: Product risk is the second most thought-out issue when purchasing used goods. As was to be expected, this happened since buying previously-owned items always come with a degree of risk due to the lack of information about their quality and function. Most of the people find their used goods on the Internet. This shopper behaviour may also heighten the dangers associated with buying previously owned items. A customer making an online purchase might, for instance, be concerned about price, delivery, quality, and performance of the product, and even the ease of making the purchase itself.
3. *Reducing overproduction*: The difficulty in estimating demand is a major problem in the fashion business that contributes to excessive waste. Because they do not want to run the risk of not meeting demand, many companies produce more of their products than they actually need.
4. *The option to purchase out-of-stock items*: Brands have realised that the launch of their resale platforms has provided them with a wealth of new data. Customers may be more likely to use resale services if they have access to data showing which products are selling well. This data could eventually lead to actionable insights that affect manufacturing decisions.
5. *Ownership of brand identity & price*: When customers resale items in collaboration with multi-brand platforms, there can be a lack of transparency around pricing; brands want to address this issue so that they can better please their customer base while also helping to create a baseline value for their own products. For fear of having their products devalued, several luxury firms have been hesitant to enter this market.

6 Conclusion

The practise of reusing previously owned items is extremely common, and there is no evidence to support the imposition of a ban on the import and export of previously worn clothing. It would appear that reusing previously worn clothing can be beneficial in a wide range of contexts, including both the past and the present. Not only does it give you the chance to find one-of-a-kind items, trial with your own fashion sense, and find incredible deals, but it also encourages a more self-sustaining and circular prospect for the fashion business. Young shoppers have shown a growing interest in purchasing previously owned clothing over the course of the past few years. Providing special offers, free trial choices, and swap opportunities after use are all additional ways to encourage the purchase of pre-owned clothing and accessories for resale. Changing the look of the product to appeal more to customers is another strategy that can be used to increase sales of the product.

The amount of used clothing being purchased is growing each day. Since buying used clothing is not just a straightforward instance of monopolies, it is essential to pay close attention to the various aspects that come into play during this type of transaction. This chapter highlights the interplay between price, risk, brand qualities, societal attitudes, emotions & experience, and market place to illustrate the influence these elements have on the decision to purchase pre-owned apparel. Therefore, the discussion and argument around problems such as brand, pricing, social attitudes, and seller location will be enriched by the ideas offered in this chapter. As a corollary of these findings, the question of how much weight the factors that impact the purchase of pre-owned garments deserve within the existing theories of customer behaviour is raised. The aim of this chapter is to contribute fresh knowledge to the fields of used clothing and the purchasing behaviours of customers.

The chapter concludes that the characteristics of brand, price, and buying intention of used clothing do not, in reality, have any correlation with or influence on each other during the process of making a purchase decision about used clothing. As opposed to brand, price, and intent, societal attitudes and geographical considerations have a weak association with one another. The study also demonstrated that the process of purchasing used clothes is distinct from the process of purchasing new clothing, as seen by the fact that customers give separate consideration to each component when purchasing used garments. Therefore, it is recommended that the vendor devote an equal amount of emphasis to the aspects of location, society attitudes, price, and brand. In addition, one needs to supply all of the necessary information that pertains to the aforementioned elements. For some consumers, the purchase price may be the deciding factor in whether or not they will make a purchase. The vendor is required to disclose all of the information that is associated with the price of the used apparel, containing the purchase price for the item, the going rate for the item, and the price at which the garment is being offered for sale. Therefore, a seller of used clothing also has a responsibility to disclose any and all relevant information, including damage to the garments, performance of the garments, durability of the garments, and/or a warranty, if the consumer is able to

obtain this type of information; this allows the consumer to more easily make a purchase decision.

In addition, the outcome of the chapter demonstrates that the client places the greatest importance on cost when deciding whether or not to purchase pre-owned apparel. The willingness to pay is another factor that plays a significant role in the purchase decision of previously used clothing. On the other hand, the price is unaffected by other elements such as the brand, the location, or the general consensus of society. Therefore, it is recommended that the seller of the used clothing should adhere to an appropriate pricing plan to ensure that a consumer will be able to purchase it. In addition, it is important for the seller to remember that the high price decreases the likelihood of being able to sell the garments (Völckner & Sattler, 2005, p. 1).

The findings also indicate that customers do not place as much importance on location as they do on factors such as brand, price, and society perception. Customers do not view location as being as essential to them. When a consumer is deciding whether to acquire second-hand clothing, he considers the location of the seller. The administration of second-hand enterprises on websites such as eBay, Amazon, and other online marketplaces, might find this study helpful when developing relevant and appropriate marketing plans based on the new information.

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The Afterlife of Waste: Sustainable Fashion Businesses & Solutions

Rishab Manocha and Mridul Dharwal

Abstract In the last two decades, the rise of fast fashion has made it feasible for consumers to purchase all types of clothing and accessories at reduced rates, which has dramatically increased consumption. This has contributed to the rapid expansion of the global fashion business. However, fast fashion has resulted in numerous environmental issues. The annual global worth of rejected clothing is $450 billion, yet the rate at which they are recycled is a meagre 12%. To alter the public's negative perceptions of the fashion industry, businesses, manufacturers and retailers around the globe are placing a greater emphasis on sustainability. Numerous apparel designers and clothing brands have pioneered the use of recycled or biodegradable materials in the manufacturing of innovative textiles. Domestic electrical wires and cables constitute a significant portion of the waste we generate. However, it is crucial to keep electrical wires and cables out of the trash since they include both recyclable materials and plastic coatings that are hazardous to the environment. In reality, a major quantity of electrical waste and scraps can be repurposed into wire suitable for textile embroidery, which would considerably improve the industry's overall sustainability. This chapter takes into consideration the case studies of three apparel and textiles designers who aim to maximise the value of waste who replace traditional embroidery techniques by usage of alternative waste materials to improve the tactile perception and other comfort aspects of current sustainable apparel. The chapter presents strategies to reduce the amount of metallic waste by giving discarded electrical cables a second life, debunking the concept of waste, and permitting the sale of eco-friendly textiles made from upcycled waste materials.

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1 Introduction

Over the past several years, the topic of fashion's non-economic implications has risen to the forefront of public discourse around the world in response to pervasive censure of the apparel industry for its lack of concern to social and ecological issues (Global Fashion Agenda and The Boston Consulting Group, 2017). This has resulted in the non-economic consequences of fashion being hoisted to the forefront of the international public discourse. The fashion industry is responsible for significant and far-reaching negative effects on the natural environment. In addition to consuming vast quantities of water (80 trillion liters annually), producing enormous quantities of textile waste (in access of 92 million tonnes annually), the industry is also contributing significant amounts of oceanic primary microplastic pollution. These are just some of the ways in which the fashion industry contributes to environmental degradation. In recent decades, both the production of garments and their consumption have significantly increased, which has led to a discernible increase in people's awareness of the effects that they have on the environment. The annual amount of textiles produced per person across the globe increased from 6 kg in 1976 to 17 kg in 2020 (Common Objective, n.d.). It is currently estimated that the annual global consumption of clothing is 62 million tonnes, with an upsurge to 110 million tonnes projected by the end of 2030. As a consequence of this, leading fashion houses are presently manufacturing approximately twice as much clothing as they did before the pandemic. The rapid expansion of both the textile manufacturing industry and the fashion industry itself led to the development of a new type of business model known as 'fast fashion' (Niinimäki et al., 2020). The provision of consistent innovation to customers in the form of competitively priced goods that are inspired by current fashion trends is at the core of this business approach. The concept of fast fashion promotes frequent, impulsive product consumption in addition to the consumption of products on a more consistent basis (Sanchis-Sebastiá et al., 2021). Its unswerving and enduring progression, its propensity to outperform in the category of traditional fashion retail, and the introduction of fresh competitors like online retailers, who are able to offer superior agility and quicker delivery of new merchandise more regularly, are all indicators of the model's success. This has resulted in an estimated 4% annual growth in the demand for the manufacturing of clothing, leading to roughly twice as many clothing collections being produced by manufacturers as there were before the start of the fast-fashion trend in the year 2000. This is because the demand for clothing is rising at a faster rate than its supply.

1.1 Impact on Buying Behaviour

The price of clothing has achieved an all-time low, which is a direct outcome of rising demand as well as innovations in production processes. This is the case in both the EU and the UK. In addition to being supportive of the fast-fashion model, low prices contribute to the growing trend of consumers buying more clothes but wearing them less frequently. Past studies have evidenced that the fast-fashion commercial model is unswervingly responsible for the increased annual purchases of new apparel. Consequently, the average article of clothing has been worn for 40% less time since 2005, and there is evidence in the UK, Norway, and other places that points to early disposal after minimal use, particularly for impulsive purchases. Many advertisers are eager to learn more about the psychology behind impulse purchases. To increase revenue, many businesses in the fast-fashion industry count on customers making spontaneous purchases. Thus, many methods have been devised to encourage clients to buy on impulse. But remorse after an impulsive purchase might affect future shopping behaviour, brand loyalty, and even brand switching. The apparel business is one of the core areas on which environmental damage is based because of its excessive output and the widespread use of fast fashion. The manufacturers and retailers of fast fashion did not give much thought to the impacts that their products would have on the environment. Rather, they placed a higher priority on getting their products out into the market as quickly as possible and reducing their production costs. Producers, merchants, and consumers alike are feeling the heat to adopt greener business practices and become more cognizant of the environmental effects of their purchases and consumption as a result of the spotlight on climate change, environmental degradation, and sustainability. Next, this chapter moves on to conduct an investigation into the water consumed, the chemical pollution, and the CO_2 emissions caused by fast fashion and will examine the specifics of fashion's waste (Stanescu, 2021). Further, the chapter will offer some perspective on how the fashion industry as a whole might be made more sustainable through actions such as reducing the production of garments and the waste that they generate, as well as maximising the use of garments and their longevity.

1.2 Fashion's Carbon Footprint

The vertical breakdown and global distribution of subsequent processes characterise the fashion industry's supply chain, which covers all aspects of manufacturing, distribution, and retail (Wang et al., 2021). Many industrialised countries have seen a dramatic decline in production, sometimes to the point of extinction, as the textile and garment industries have migrated to countries with lower labour costs. At the same time, complexity has increased along the supply chain, and transparency has decreased. The history of the processing of raw materials and where they came from could be unknown to downstream manufacturers. Of the fibres produced, 70% are

destined for the fashion sector, while the remaining 30% are used in many other applications, such as home furnishings, industrial textiles, geotextiles, agricultural textiles, and hygiene textiles. In 2021, cotton was responsible for 27% (or 26 million tonnes) of the world's textile production, while synthetic polyester was responsible for 40% (or 54 million tonnes). It is anticipated that production of polyester, which currently dominates the market due to the performance characteristics it possesses and the cost effectiveness it offers, will increase as consumers in developing nations in Asia and Africa adopt western lifestyles. To complete wet manufacturing processes such as bleaching, dying, and finishing, significant amounts of water and energy are required. Worse still, there is a significant amount of waste generated throughout the process of manufacturing textiles. Fabrics that have been treated are sent to textile mills to be made into garments. Garments require not only textiles but also trims such as lace, buttons, zippers, linings, labels, and buttons, all of which come from different nations and so necessitate a vast amount of labour-intensive jobs. This results in a growing demand for skilled manual workforce in the production of apparel. Over the course of the previous few decades, textile production has transferred from developed to emerging countries due to the lower prices of manufacturing and labour in the latter. For example, China has a dominant share of the market and annually exports textiles worth $115 billion USD and garments worth $165 billion USD. China's textile exports have expanded in response to expanding demand in countries such as India, Pakistan, Bangladesh, Vietnam, Cambodia, and Indonesia, although the country's share of the export apparel market has dropped in recent years. Because of the distance, it is more likely that mistakes will be made in the planning of the production, which will lead to an excess of pre-consumption waste. Bulk orders of completed garments are often shipped to the USA, the European Union, and the United Kingdom when production is complete. Air freight has become increasingly popular, especially among e-commerce businesses, despite the fact that container ships have been the industry standard for delivering clothing for decades. The predicted increase in carbon emissions is caused by the transfer of only 2% of apparel shipments from ship to air cargo (Wang et al., 2021). This shows how much more of a toll aviation cargo has on the environment than previously thought. The enormous supply networks required to translate raw fibre farming into a finished outfit also increase the likelihood that the outfits have been shipped around the world more than once. When they have outlived their usefulness, the vast majority of clothes are either discarded in landfills or sent to Africa or other regions of the world that are economically developing.

2 Textile Waste

The rapidly expanding fast-fashion sector has been linked to a rise in the amount of waste produced from textiles, which has led to concerns about the environment. Throughout history, developed nations have dealt with their excess of textiles by exporting their used clothing to less developed nations such as India and Africa.

There are, however, a number of reasons why this is impossible. In an effort to save their native textile industries, many emerging nations, including Turkey and China, have outlawed the import of textile waste. This has led to an oversaturation of markets with pre-owned apparel, which has in turn harmed the local manufacturing sector.

2.1 Pre-Consumer Textile Waste

Fabrics that were not sold to customers and were discarded by producers or stores, often known as 'pre-consumer' fashion waste, include materials such as waste fibre, yarn, and fabric. Fabric scraps are the most resource-intensive byproduct of the textile and apparel industries. Depending on the type of clothing, the rate might range from 10% for pants and jeans to greater than 10% for tops and outerwear. One study found that only 15% of textiles were thrown away during the production of clothing, although other estimates put the figure as high as 25%. Excess waste can be influenced by a variety of factors, such as the textile's width and surface texture (for example, larger waste is related to one-directional prints). During the cutting process of making clothes, fabric scraps are produced. The quantity of these offcuts is determined by the overall design of the garment as well as the precision with which the flat patterns were generated to be laid on the fabric. In addition, errors made during assembly are the cause of wasted clothing. The growth of the global fashion industry has been accompanied by an increase in the quantity and variety of waste generated during production. It is important to slow down the manufacturing process and increase accuracy in production to reduce waste that occurs during the pre-production phase. Better communication between designers and factory workers is key to achieving this goal. Unwanted stock, a form of pre-consumer trash, has received a lot of attention in recent years. This type of waste is comprised of new, unused clothing that is either not sold (or is returned, particularly when the item was purchased online) and is subsequently referred to as 'garbage'. As an example, a 2016 report in Ecotextile News suggested that just 30% of imported clothes in the EU sell at full price, while another 30% sell at a discount and the remaining 30% do not sell at all. It was projected, with a high degree of certainty, that 21 million items of clothing went unsold in the Netherlands in 2015. This amounts to 6.5% of all clothing, and two incidents in 2018 provided fresh insight into unwanted stock. Sweden-based fast fashion global retailer H&M has been held responsible for burning down a waste-to-energy plant in Denmark, instigating speculation that the company has $4.3 billion in unsold merchandise sitting in warehouses. As of June 2018, it was reported that Burberry, another high-end British label, had wasted £90 million worth of unsold stock over the course of the previous 5 years; the company admitted to wasting $28.6 million worth of inventory in 2017. The incineration of waste results in the 'recovery' of some of the energy contained within the items, but it also results in a greater number of emissions and other air pollutants than either recycling or reuse. However, when viewed in the context of the entire apparel life

cycle, the carbon emissions from the incineration of clothing are found to be insignificant. The majority of garment carbon emissions result from the production of textiles as well as normal wear and tear. However, the greater issue is the waste of resources (electricity, material, water, and chemicals) that has resulted from the production of unsold clothing.

2.2 Post-Consumer Textile Waste

Recycled materials are those that were once produced for use in the textile trade. In 2012, the global apparel industry produced an estimated 150 billion knit garments, of which a significant portion was returned to manufacturers by customers very soon after purchase. Since this was a return initiated by a consumer, it made up a sizeable chunk of the total. What is being referred to here is a collection of garments that, once production was finished, were not needed anymore and were subsequently thrown away. Despite the significant differences that exist between them, most knit clothing has an average lifespan of only 3.1–3.5 years per item and wears out the quickest. The USA and UK worked together on this project. Since 1999, there has been a 40% increase in the amount of unwanted clothing that ends up in American landfills. A number of significant occurrences between 1999 and 2014 have led to this increase. About 22% of all trash created worldwide is made up of textiles. Both rising consumption and shorter garment lifespans may be contributing to this trend. Consumers are also reducing the amount of time they retain their clothing. Of the fibres generated in 2015, 73% were disposed of in landfills, totaling 39 g/t (Anguelov, 2016). Both the UK and the USA have high rates of textile waste (30 kg per person per year). This is a significantly bigger amount than either Finland (13 kg) or Denmark (16 kg). In 2015, less than 1% (0.5 million tonnes) of textile manufacturing was recycled in a closed loop system. This was true even when garbage generation rates were on the rise. This occurred despite the fact that waste rates have remained rather high. Nearly all of the 6.4 million metric tonnes of recovered textiles were put to use in low-value ways, such as insulation, cleaning rags, and mattress filler. In addition, the gathering and processing of the textiles resulted in the loss of 1.1 million tonnes worth of material. On the other hand, Italy and Germany do not have any infrastructure for recycling textiles, despite the fact that they are responsible for 11% of the worldwide textile waste produced annually. The UK recycles at a rate of 11 kg per person, making it the second most environmentally conscious nation in the world. The nation's higher-than-average use of textiles and garments is one aspect that contributes to this situation. The research that was done on textile collecting in European communities as part of the European Clothing Action Plan suggested that these differences be taken into consideration (European Commission, 2020). The inquiry was centred on examining the social structure of urban Europe. Closing the material loop and establishing an operational recycling system for all waste textiles requires widespread support for recycling garments. Only if people are willing to accept the idea of recycling clothing will this be

possible. Additionally, it is crucial that both the manufacture and consumption of clothing be slowed down.

3 A Shift in the Paradigm

Normal operations in the fashion businesses prioritise output and revenue growth over product quality and lifespan, resulting in wasteful material use, rapid consumption, and negative environmental impacts. Inefficient material flow, high rates of consumption, and environmental damage are the result of all of these problems. These factors add up to an inefficient use of resources, a high rate of consumption, and negative effects on the ecosystem. Since this is the case, adjustments must be made to both manufacturing methods and consumer mindsets. However, this cannot be accomplished without the participation of all relevant parties, such as the investment in clean technology by the textile trade, the development of new business models by the fashion industry, the adaptation of purchasing practices by the consumer market, and the revision of existing laws and global business rules by the political and economic spheres. Further in the chapter, the authors discuss how regulating population growth, reducing or eliminating waste, and fostering the development of a CE are all essential steps toward establishing a new standard for the manufacture of environmentally friendly clothing.

3.1 Circular Business Models (CBMs)

Recyclers of textiles are turning to Circular Business Models (CBMs) to address the dual challenges of reducing environmental damage from improperly dumping massive amounts of textiles and meeting consumer demand for such goods. Because of this, it is clear that certain businesses' current procedures need to be drastically altered if they are to continue expanding. It has been argued that there is a deficiency in our knowledge of the causes and constraints that are hindering the acceptance and execution of CBMs in the textile recycling trade. These considerations highlight the need for more focus in empirical studies on this issue.

Recapturing value in a way that is both sustainable and economically viable requires a CBMs (Wrålsen et al., 2021). Models of companies that recycle their resources back into the system have become the need of the hour. How a company generates, disperses, and collects value while maximising the useful life of its resources is the focus of CBMs (Frishammar & Parida, 2018; Nußholz, 2017). CBMs examine the processes by which a business creates, disseminates, and reaps the rewards of that value. Keeping and making the most of one's resources are two of the most important factors in a company's long-term success. There are issues pertaining to the inception process of manufacturing, which need to be tackled before trying to predict what will happen to the product at the end of its lifecycle. It

is not just the textile industry that has this issue; the cause of the problem lies in the very first stage of manufacturing. Wrålsen et al. (Wrålsen et al., 2021) state that CBMs are implemented to stop, postpone, or lessen the outflow of a resource to prevent or minimise the loss of value. This action is taken to stop or lessen the value decline. CBMs, as stated by Bocken et al. (Bocken et al., 2013), are strategies that integrate and support an enterprise value plan with the foundation, distribution, and capture of value. An enterprise value proposition is also a part of CBMs. When describing CBMs, Hultberg and Pal (www.topcable.com, 2020) take a slightly different approach than other researchers. That which follows the ideologies of the CE is, in their view, a CBM. Restoration and remanufacturing, recycling, and cascading and reusing are some more CBMs. Many companies in the European Union's automotive sector practice CBMs as part of their CE strategy (Albertsen et al., 2021), which includes heavy use, maintenance, repair, refurbishment, remanufacturing, repurposing, and recycling. Research conducted by Lieder and Rashid (Lieder & Rashid, 2016), differentiated the '3Rs' (reduce, reuse & recycle) into their own categories of CBMs. The studies' results paint a picture of existing circular procedures and hint at the possibilities for various operations of CBMs in actual business practice, while also highlighting some commonalities. Further, the results of their study suggest a few shared features. Due to the unique characteristics of various economic sectors and the need to tailor business practices to the products and services on offer, CBMs must be altered on a case-by-case basis. A fully circular economy would not generate waste since all products would be recycled via various resource cycles (Masi et al., 2018). While some CBMs encompass the full flow of resources, others may only address a single process and hence require additional CBMs to complete the loop (Masi et al., 2018). These cycles are responsible for the production of a diverse range of CBMs, also referred to as the '*new economy*' or '*new consumption*', which are becoming increasingly popular (Bocken et al., 2016), and offer a feasible substitute to the conventional linear patterns of manufacturing and utilisation. This satisfies a need for a practical substitute to the prevalent industrial and consumerist models. The 'R-activities' found in CBMs are uncommon in the more traditional linear business models. To strike a balance between resource conservation and the increase of economic value, CBMs capitalise on the product's inherent economic and environmental benefits (Bocken et al., 2016). To create value, businesses that follow a CBM, put the ideologies of a CE into action. It is possible for a business to reduce its resource use, freeing up funds that can be invested towards the development of truly useful merchandise rather than wasteful by-products. They may produce inputs for use by other market participants, or they could devise a system to handle the inputs used by their own business. This operational model provides support for the idea of increased manufacturer accountability. The manufacturer is responsible for the product until it has reached its maximum useful life (Bocken et al., 2016). Therefore, it is possible that environmental damage may be drastically reduced (Ferasso et al., 2020) if such economic models were built with care (Tukker, 2004, 2015). To be able to shift from a linear to a circular model of doing business, companies need to reevaluate their value creation, acquisition, and distribution processes. Enterprises are already motivated to investigate

CE-based value propositions and develop CBMs (Bocken et al., 2013) by the enterprise's values (goals), strategy, and economic prospects. CBMs give businesses an edge in the market, boosts customer loyalty for their brands, reduces waste management costs, and addresses regulatory waste standards. By doing so, firms can boost productivity and get closer to achieving their zero-waste objective. This means that these business models play a crucial role in laying the groundwork for brands to create and reap value (Clauss et al., 2020; Kraus et al., 2020).

3.2 Influencing Factors

The textile recycling industry, for example, stands to gain financially from the adoption of Circular Economy (CE) policies. Businesses in this industry may take an interest in CBMs if fostering sustainable development comes to be seen as one of their key responsibilities. Companies could work together to reduce environmental damage from collecting, sorting, and disposing of '*post-consumer rubbish*' and '*industry/pre-consumer waste*'. Furthermore, this is of the utmost importance because it is predicted that global textile waste would increase by 60% annually between 2023 and 2030, increasing annual waste production from 57 million to 148 million tonnes (Global Fashion Agenda and The Boston Consulting Group, 2017; European Commission, 2020; Xu et al., 2019; Lu et al., 2019). Furthermore, the production of textile waste results in a potentially enormous loss of value and commercial opportunities throughout the entire textile and garment production chain (Global Fashion Agenda and The Boston Consulting Group, 2017). CE advocates such as Payne (Government of the Netherlands, 2022) and Jamshaid et al. (Niinimäki et al., 2020) argue that all waste products should be recycled or repurposed. This is a contributing factor. There is no question that we could greatly lower the demand for completed goods and fibres if we increased the longevity of garments and found creative ways to reuse textile trash (Niinimäki et al., 2020). Businesses are expected to provide more attention to the CE in the near future (Ferasso et al., 2020; Dazed, 2021). This is because there is a potential for a dramatic increase in textile waste, necessitating the usage of circular products to combat the problem. Although the private sector as a whole is quite excited about CE, only a small fraction of CBMs are actually being put into effect in this field (Wang et al., 2021; Anguelov, 2016; European Commission, 2020), making discussions about CE and CBMs crucial for everyone involved in the textile recycling business. In the last few years, circular reuse business models (CBMs) have emerged, mainly in Poland (see, for example Nast & Vogue, 2020) in the context of the potential of managing pre-owned clothing. Many of these CBMs are made in an effort to stop or at least significantly slow resource cycles. This demonstrates how different businesses, including the textile recycling industry, will need to adopt notably diverse approaches to the design and implementation of their business models to make the transition to CE in the here and now. Most corporations are focusing on the more idealistic goal of producing value in a circular shape (Colossal, 2020), which requires a shift from their current

creative linear economic processes, which are characterised by substantial experimentation. Yet there is no universal agreement on which materials can and cannot be recycled. This includes the frequent practice of excluding energy recovery and fuel production from the definition of recycling when it comes to textile waste. Because there are many various points of view on the subject as well as methods to interpret the data, there is a lot of disagreement and contradiction even in the numbers that apply to recycling. This is because there are many different ways to interpret the data. Recovering energy and creating fuel from textile waste are not examples of recycling, per European (Hitti, 2020) and national (https://handembroidery.com/aniela-fidler/, n.d.) rules. As an additional reminder, consider this. While it is possible that other companies have already taken some steps in this regard, we do not know very much about them at this time; still, it is crucial to underline that in Poland, VTR is actively involved in trying to enhance the existing CBMs toward more sustainable CBMs. This is so even when we know relatively little about competing companies (e.g. Wieruszewska, n.d.). Previous studies have shown that in order for businesses to successfully recycle textile waste or reuse previously owned items, they must first adopt and then refine appropriate business models (BMs) (Elnaz Yazdani Embroidery, n.d.). Thus, it is necessary to fortify the drivers for CBMs to achieve greater degrees of circularity (i.e. Schaffner, 2020; Lemille, 2019; Hysa et al., 2020). Eliminating the obstacles that currently limit the development of CBMs is a vital first step toward maintaining the transition toward a more CE (i.e. Li et al., 2017; Masi et al., 2018). To a greater or lesser extent, many business models and organisational structures face varying sets of motivators and constraints (Li et al., 2017). Because of this, there is a lack of knowledge on the factors that encourage and discourage innovation in textile recycling's CBMs. Despite the fact that a large number of these studies have been published in a relatively short amount of time, the structures and discourses of these studies are not well established and are not interconnected. It has been noted by Ferasso et al. (Ferasso et al., 2020) that the existing state of knowledge about CBMs is not well understood. It is unclear whether aspects of CBMs have been understudied or which could benefit from greater investigation, or which should be prioritised in future studies.

4 Electronic Waste

The accumulation of hazardous e-waste in the environment, including soil, air, water, and living beings, is dangerous due to the fact that hazardous e-waste cannot be decomposed. The buildup of hazardous e-waste in the environment is harmful. When salvaging metals and other valuable components from old electronics, practices such as open-air burning and acid baths are sometimes used (Cui & Forssberg, 2003).These practices result in the discharge of toxic compounds into the surrounding environment. Because of these procedures, toxins such as lead, mercury, beryllium, thallium, cadmium, arsenic, brominated flame retardants (BFRs), and polychlorinated biphenyls can be released into the workplace. Cancer, miscarriages,

neurological impairment, and lower IQs are just some of the negative outcomes that have been related to these pollutants in human studies.

A group of researchers produced a paper in 2019 titled '*A New Circular Vision for Electronics – Time for a Global Reboot*', which proposes to examine electronic waste through the lens of the circular economy concept. This would require a system that is both regenerative and capable of reducing the amount of lost waste and energy. There are numerous dissimilar UN establishments that make up the E-waste Coalition, including the UN Environment Program (UNEP), UNIDO, UNU, and the Secretariats of the Basel and Stockholm Conventions. The findings in this research are helpful to the E-waste Coalition in their efforts. According to the findings of this research paper, the improper disposal of electronic trash is causing an alarmingly high rate of loss of precious metals such as neodymium and indium, which are both utilised in the production of motor magnets and may be found in flat-screen televisions. Rare earth elements are practically never recovered using non-ethical recycling procedures due to the severe detrimental consequences their mining has on the surrounding ecosystem. The metals can be recovered from e-waste, but it is a laborious process. For example, the cobalt recovery rate is only 30%, despite the fact that technology could recycle 95% of it. Despite this, the metal is in high demand since batteries for electronic devices such as laptops, smartphones, and electric vehicles require it. When compared to the energy needed to smelt the same quantity of metal from raw ore, the amount of energy required to recycle metals is anywhere from two to 10 times lower. In addition, the amount of carbon dioxide released during the process of extracting gold from outmoded electronics is 80% lower than during the process of extracting gold from the earth.

In 2015, the process of extracting raw materials was responsible for around 7% of the total energy consumption across the globe. Therefore, a significant step toward fulfilling the goals specified in the Paris Agreement on climate change could be a shift towards the use of more secondary raw materials in electronic goods. This is because secondary raw materials have a lower environmental impact than primary raw materials.

4.1 Circular Approach for Electronics

There needs to be a fundamental change in the way that electronic and electrical goods are manufactured as well as consumed. In spite of the fact that there is a tendency to classify e-waste as a post-consumer concern, the reality is that the problem spans the whole product life cycle of the electronics that we all use. Reducing waste, maintaining value within the system, extending the economic and physical life of a product, and maintaining the capacity to repair, recycle, and reuse, are all collective goals that require participation from a wide range of stakeholders, including product designers, manufacturers, investors, merchants, miners, raw material producers, consumers, and policymakers. The *computer cloud* and the *Internet of Things* (IoT) are two technological trends that could one day lead to the '*dematerialisation*' of

the electronics industry. Because of the rise in popularity of service-based business models and the progress made in product monitoring and takeback, it is feasible that global circular value chains may arise in the near future. Material scalability, recycling infrastructure, and material efficiency are going to be necessities if we are going to meet the requirements of electronic supply chains and increase the amount of recycled materials while maintaining their high level of usability. This sector has the potential to create millions of high-paying jobs all over the world if the right policy combination is implemented and it is managed effectively.

4.2 Electric Cables: Characteristics and Qualities

Cables are a crucial part of many industries, including those related to transportation, building, communication, and consumer products. It is possible to further classify the many various kinds of cables into subcategories depending on their construction, manufacturing method, intended use, and other characteristics. The five most common kinds are as follows: first come magnetic wires, followed by uninsulated counterparts, then both electrical wires and cables followed by power cables, and lastly communication cables. There are also many subtypes of each of these five primary categories. Despite the fact that cables can be manufactured in a wide variety of shapes, their design must always adhere to all standards and requirements that are applicable to the local, national, and international levels. Low voltage, medium voltage, and high voltage cables are the three main types of electrical cables that can be distinguished from one another by the voltage at which electricity is transferred. Lines that operate at medium voltage are used to transmit power. Some examples of low voltage cables include control cables, instrumentation cables, solar cables, special cables, aluminum cables, and armoured cables. Solar cables are also included in this category. Solar cables are an example of a different kind of low-voltage wire. Besides the varieties already mentioned, there are also halogen-free cables, fire-resistant cables, armoured cables, rubber cables and solar cables. Each conductor's diameter determines whether a cable is thin (within the millimeter range) or thick (in the cm range). Insulation, auxiliary devices (which protect the cable and ensure that it will last for as long as possible), and an outer sheath are all components that make up a cable. The electric conductor, which is a core made of a conductive metal such as copper or aluminum, is a necessary component for the operation of any device that uses electricity (Li et al., 2017). Polyvinyl chloride (PVC), polyolefins (PO), linear polyethylene (PE), and polyurethane (PU) are examples of thermoplastic insulation materials. Fibreglass, cellulose, and aluminised paper are examples of thermoset insulation materials. Thermoplastic insulating materials include polyvinyl chloride (PVC), polyolefins (PO), linear polyethylene (PE), and polyurethane, with ethylene propylene, cross-linked polyethylene (XLPE), ethylene vinyl acetate (EVA), silicone, neoprene, and natural rubber being the most common (PU). An 'armoured' cable is one that has been reinforced with an outer metal sheath.

4.3 Recycling Techniques of Copper-Containing Waste-Cables

Although they may be thin, recycling old wires involves a more involved process. Thick waste cables can be recycled in a simple, modern fashion, for instance, by stripping them or crushing them into small scrap nuggets before being sorted, while thin waste cables cannot.

The following are some of the steps involved in these multi-stage processes for efficiently removing copper from plastic:

- Crushers, strippers, ultrasonic separators, hot water treatment facilities, cryogenic facilities, and high-pressure water jets are all examples of technology used for mechanical treatment.
- Chemical water-purification methods and related technologies include process such as dissolution and cementation, chemical- or bio-leaching, or chloride volatilisation.
- Recovery of both heat and energy such as incineration and thermal decomposition are techniques meant for establishing space between two entities. One of these is by the use of gravity. Gravity separators employ many techniques, including jigging, shaking tables, electrostatic separation, flotation, and others, to separate materials based on differences in density, size, and shape (www.top-cable.com, 2020).
- Rough sorting of trash cables must be done manually in the initial phases of creating mechanical treatment technology for recycling. The plastic shell and copper core are then separated and recycled separately.

4.4 Stripping Technology

A stripping machine is used to process the cables after they have been gathered, categorised according to diameter, and sorted. Although the basic premise of a stripping machine is straightforward, the actual process can take a significant amount of time depending on the machinery employed and the volume of scrap being removed. After the cables have been gathered and categorised by diameter, a stripping machine is used to process them. As the cable is fed into a feed port and the wire is pushed through by an electric motor, the insulation is stripped off by hand. The operator will then either actively peel the cable or wait for the insulation to fall off on its own, depending on the diameter of the wire and the environmental factors at play. Despite the high level of automation it possesses, this machine can only be used to strip wires of a specific diameter, which severely limits the applications for which it can be put to use. Consequently, its usefulness is severely constrained. Because of this, researchers and businesses that deal with abandoned cables have made significant progress toward the development of alternatives to the conventional wire strippers that are both more effective and more convenient. These new wire strippers combine the best features of the traditional tools.

4.5 Crushing Technology

Used cables are first processed by crushers, which reduces them to particles of a predetermined and uniform size. This is done before the used cables are processed by a sorting gear. Further, these particles are subjected to additional processing, during which they are transformed into plastic rice and copper rice. The machinery used in this process is referred to as '*copper rice machines*', and it is made up of several different units that are used for crushing and sorting the copper rice.

5 Recycling Electric Waste: A Step Towards a Circular Economy (CE)

Sources of waste-cables include defective cables during production (cables with issues related to the insulating substance). These cables at the end of their useful life, are obtained during building repair and electro-installation. Waste-cables can be recycled into new cables. These cables that get thrown away, make a significant contribution to the problem that they helped create. Improving our methods of waste management is one of the first steps toward creating a CE (www.schoolofsustainability.it, 2019).

By rethinking the conventional approaches to production and consumption, the CE seeks to accomplish its primary objectives of cutting down on waste and maximising the use of available resources. If we are truly concerned about the state of the planet, we can no longer adhere to the outdated economic models that are predicated on resource extraction, production, consumption, and disposal. If we want to lessen the impact that economic policy has on the health of the environment, we will need to see a change in that policy. Because of this, to establish a CE, one must not only refrain from throwing away items but instead fix, recycle, and reuse them; in addition, one must acknowledge that the natural resources of the Earth have a limited supply. Reusing, redistribution, and/or remanufacturing components, as well as other life-extension practices, are encouraged within a CE because they extend the useful life of components. It is possible to increase a business's ability to weather unfavourable economic conditions by adopting precautions to preserve the value of the company's product components and, at the same time, reducing the impact of the unpredictability that exists in external markets. However, to achieve this, the CE necessitates the recycling of materials that were previously considered waste.

The prevention of wasteful production and consumption ought to be given the highest priority. Because recycling rates are currently relatively low all over the world, the next crucial step is to improve those rates. A definitive model for a CE has not yet been developed, despite the fact that the idea of such an economy is gaining popularity. Producers, consumers, and policymakers are only few of the many groups whose participation and dedication are essential for a smooth evolution from a linear to a CE model.

As much as 95% of the weight of the plastic insulation around trash cables is made up of non-ferrous metals such as copper and aluminum, making them the most treasured constituents of waste cables that should be recycled. Following its first use as an insulator or sheath, thermoplastic can be pulverised and recycled into new products. Metals and plastics are two examples of non-renewable materials that can be recycled for the greater good of society and the planet. If diverted to a recycling facility, this material will not end up in landfills or on the backs of ships to underdeveloped nations, where it will add to the mountain of trash there.

There may soon be nowhere to put trash if we do not recycle the valuable copper core and plastic from cable. Trash disposal costs have skyrocketed as a direct result of the rising demand for landfill space. Subterranean metals and plastic trash may potentially pose a threat to wildlife and nature. Years after landfills have closed, soils still contain elevated levels of metals (such as iron, copper, nickel, and zinc), suggesting that they may be sources of environmentally damaging elements. Some examples of these elements are iron, copper, nickel, and zinc. From evidence suggesting that landfills could be rich in certain metals, this is the case. This is due to the fact that past research suggests that heavy metals might be entering the ecosystem via garbage dumps. Landfills are a major contributor to this issue. Metals such as copper, cadmium, and lead were detected in leachate, soil, and plants in the area surrounding the rubbish and waste piled up on both sides of this area. Most well-maintained landfills are lined with impermeable materials to keep water from seeping out and polluting the vicinity around the dump. Local contamination is possible if this step is skipped or the liner is not replaced when it wears out. Even if this procedure is not followed, the result will be the same. Landfill water may include small concentrations of harmful metal stabilisers, but these levels are much lower than those found in other forms of municipal trash (Xu et al., 2019). Regardless, the concentrations in landfill water are much lower than those in other municipal trash. Since this scenario is similar to one in which plasticisers spread from soft PVC due to bacterial action, we can say that these two situations are comparable. Due to their decomposition, they are no longer a significant source of groundwater pollution. PVC trash in a landfill leaches harmful substances into the groundwater, which has severe and far-reaching effects on the ecology. The waste's toxicity and leeching properties pose serious threats. PVC burns in a landfill, creating dangerous air pollutants (like dioxin) that can make their way into the food chain, adding to the already poor air quality. Therefore, PVC is among the most dangerous materials available. We are in a particularly precarious spot. There is a universal consensus that materials that cannot be decomposed by natural processes, including plastic and metal, should not be discarded in landfills.

It is common practice in less developed countries to destroy electrical and electronic garbage by setting it on fire (including mobile printed circuit boards, laptops, and waste-cables). Some examples of these kinds of countries are China and India. Even after the fire has reduced the material to ash, the copper would not melt but will instead remain in a solid state. Because of this, getting rid of the copper is a breeze. If this trash is burned with open flames, it could release harmful substances into the air. Consequences for the local environment are sure to be negative and

quick. Subterranean sediments, streams, and surface water are popular repositories for poisons, so their influence is indirect rather than immediate. The insulating coating of PVC wires and cables is burned by informal workers (typically youngsters and teenagers) for 10–12 hours per day in many parts of the world (Lu et al., 2019).

These workers are located in countries such as Ghana, China, India, Nigeria, and the Philippines. This causes a cloud of thick, dark smoke that hangs around in the air for a significant amount of time after it has been produced. In the majority of workplaces, employees are required to handle potentially dangerous products without receiving adequate training or protective gear. It would be inefficient to concentrate solely on metal recovery while ignoring the material that makes up the insulating layer or sheath. When old cables are recycled in the right way, their individual components—including metals and polymers—can be repurposed without requiring any additional processing.

5.1 Advantages and Disadvantages of Recycling Electric Waste

The many different approaches to recycling used electric cables each have their own distinct set of advantages as well as disadvantages. Although all of the different approaches to recycling old cables aim to achieve the same result, the ways in which they do so can vary greatly. Because it is an uncomplicated and inexpensive method, mechanical therapy is by far the most common form of treatment. The process has a number of drawbacks:

- Production of dust and noise pollution
- Limited scope of application
- Manual cutting at the outset of the crushing process, which wastes a lot of human resources and is inefficient
- Production of high temperatures and high levels of heat because of friction between the equipment and the waste cables.

These drawbacks combine to make the process less desirable. Therefore, it is of the utmost importance to develop cutting and sorting technology for trash cables that is simultaneously highly effective and consumes a small amount of energy.

Using cryogenic shredding technology, which utilises liquid nitrogen, has many benefits when processing used cables. Accessibility, user-friendliness, a low degree of essential technical engagement, and ease of management are just the tip of the iceberg when it comes to the possible benefits that it may give. The extensive use of liquid nitrogen across the entirety of the manufacturing process is the primary factor behind the astronomically high operational expenses incurred by the company. Only by developing the technology of refrigerants and streamlining the method will it be possible to bring down the costs of the cryogenic grinding process. Ultrasonic separation is one form of recycling that does not impact the material in any way, whether it its physical or chemical qualities. Thus, this recycling method is appropriate for recycling materials such as plastic and copper. An alternative form of recycling that

does not affect these qualities is mechanical sorting. Another method of recycling that meets the requirements of this criterion is known as high-pressure water jet cutting. However, the comparatively low processing volume required makes it difficult to adapt these treatment procedures for use in industrial settings. Secondary contamination is more likely to occur during chemical treatment because the chemical components required, vary depending on the plastic material in waste-cables and because of the high volume of solvents used throughout the treatment process. These issues prevent the widespread application of chemical processes in industrial settings, hence new technologies are needed first. With the use of this technology, we can now gather a sizable amount of recyclable plastics in a variety of forms. Although incineration is a basic treatment method, it has a number of downsides, including a significant decrease in the purity of the copper due to the surface of the core being extensively oxidised. Smelting and electrolysis are required before recycled copper may be used in the production of copper products, adding time and money to the manufacturing procedure.

Toxic metal compounds including copper metal, copper oxides, mixed oxides, and copper sulphide are produced from the oxidised copper in the cables, and these compounds are then released as waste in the form of bottom and fly ashes. Most cable insulation is made of thermoplastics and flame-retardants, which means that smoke and gas emitted during a fire might be harmful. Problems have a substantially higher risk of arising if there is not rigorous monitoring of the situation. Accidental fires, unlawful recycling practices, and open burning at landfills are just a few instances of the kinds of behaviours that can have significant ramifications for both the health of humans and the health of the environment. Incinerating trash in facilities that must adhere to stringent rules should not be dangerous because of the availability of advanced flue gas cleaning technologies. It is imperative that existing incineration technologies be improved, but this does not negate the need for the creation of new, environmentally friendly incineration technologies. Used cables can be recycled to their maximum capacity and securely destroyed after undergoing a thermal recovery procedure. Potential alternatives to natural gas and propane could be produced by the costly pyrolysis of waste polymers comprising PVC; however, this process is energy intensive and thus costly.

When recycling old cables, one has to make sure they use the appropriate technology. If the goal is to achieve the highest possible purity of the separated materials, the plastic that has been separated from the metals ought to have a copper concentration of close to 0%. This is the only way to achieve this goal. The most ideal solution would be a method that could be applied to a diverse selection of cables, each of which would have a distinct core or sheath material, diameter, and other characteristics. The ideal treatment system would be one that was efficient, completely automated, environmentally friendly, and affordable.

5.2 Recycling Copper Wires

Copper, being a material, has the potential to be recycled indefinitely due to the fact that it can be used in so many different applications, since recycled copper retains all of its useful properties and may be reused numerous times, it accounts for a sizable fraction of all copper used today. Copper recycling provides several benefits, including monetary savings, environmentally beneficial consequences, and a reduction in the amount of garbage sent to landfills. When scrap copper is sold, it can fetch anywhere from 85 to 95% of the price of pure copper depending on the market conditions at the time. This is because copper can be used in such a wide number of applications. Copper is a trace metal that is essential to the health of a diverse range of species. Because of this, it is absolutely essential that at least part of it be conserved (recycling contributes to conservation this resources). To phrase it another way, copper ore is a resource that does not automatically replenish itself. When it is gone, it is gone for good; the ground will never again offer any more of it to be extracted, and once it is gone, there will be no way to get it back. In reality, only around 14% of the copper found in the ground is ever mined and utilised in any way. The extraction and processing of copper results in the production of a significant amount of waste, which includes gases such as carbon dioxide and sulphur dioxide. Only trace amounts of potentially hazardous gases are created when recycling copper, and those amounts are extremely low (for instance, by reusing copper scrap, we are able to lessen our CO2 output by 65%). This issue has a solution that can be implemented because recycling copper is a feasible option that can assist businesses in meeting the ever-increasing demand for copper. It is therefore good that this problem has an answer that can be implemented. Only about 10–15% of the energy that would ordinarily be required to extract copper from its ore can be saved whenever copper is recycled. This is because recycling only saves about 10% of the energy. Energy conservation can have a multitude of beneficial consequences on the environment, one of which is the safeguarding of commercially significant oil, gas, or coal resources. This is just one of the numerous ways in which the environment can benefit from energy conservation. Because recycling consumes less time and money than mining and refining virgin copper, products made from recycled copper can be sold at prices that are more in line with the expectations of consumers. This allows recycled copper to be used in products that are sold at prices that are more in line with the expectations of consumers.

5.3 Recycling PVC

PVC, in contrast to many other polymers, has a longer history of recycling. The practice of recycling this material has a wide range of positive repercussions, not only on the natural world, but also on the social lives of people. For example, high-tech mechanical recycling systems can be used to recycle PVC, and there is a

substantial amount of waste PVC that can be recycled. If this garbage is recycled, it will contribute to the achievement of goals related to resource efficiency, it will help preserve raw resources, and it will minimise the amount of waste transported to landfills as well as the amount of emissions. According to the findings of a number of studies, there is a total of eight various procedures that may be utilised to recycle PVC before the formation of any structural damage. PVC is a versatile and frequently superior material because it can be adjusted to improve safety and environmental efficiency without sacrificing its technical proficiency. This enables PVC to be used in a variety of applications without compromising its quality. Thus, it is an excellent choice for a considerable number of different kinds of applications. PVC is distinguished from other materials by a number of important characteristics, including its malleability, which is just one of those characteristics. If certain components are utilised, there is a good chance that the total amount of time necessary to finish this process will end up being longer than what was first anticipated (e.g. chlorine, cadmium, lead). Depending on the particulars of the process, the amount of energy required to generate PVC from recycled materials is between 45 and 90% less than the amount of energy required to produce PVC from virgin materials. Thus, its creation decreases the amount of damage caused to the environment, which is a good thing considering that the production of virgin PVC can be harmful to the environment if the process is not managed very well. Since less of the earth's natural resources are needed for the production of virgin PVC, this is a practice that contributes positively to the health of the environment. By using recycled PVC, one may cut down on both the quantity of water required for the production of PVC as well as the emissions that may contribute to global warming. Simply by recycling one tonne of PVC, it is possible to avoid the emission of almost two tonnes of carbon dioxide into the environment. This is a significant reduction in emissions. After considering all of the options, it was decided that PVC recycling would be the most economical way to get rid of this trash. Nearly 1500 new direct jobs were created in Europe's recycling factories as a result of the record-breaking year for PVC recycling (740,000 tonnes recycled). Increases in sorting and recycling capacity are predicted to provide over 200,000 new jobs in Europe by 2030 (Government of the Netherlands, 2022). This estimate was derived from recently released forecasts. The goal of 'CEs' is to salvage and use as much of the material that would otherwise be lost throughout the multiple processes of dealing with obsolete cables. This is the ultimate goal of using CE in this way.

6 Case Study 1

Designer: Alexandra Sipa
Nationality: Louisville, Kentucky, USA
Founded: 2020
Primary Industry: Sustainable Textiles
Website: https://alexandrasipa.com/

6.1 Background

Born in Bucharest, the capital city of Romania, Alexandra Sipa is currently making news in the Fashion & Textiles industry. Since she graduated from the prestigious Central Saint Martin's College of Art & Design, UK, and shortly thereafter launched her own business, her designs have been featured in publications such as Vogue, Vanity Fair, Dazed, and Elle Romania (Dazed, 2021). She began her career in the fashion industry in May 2020 and it is comforting to know that she accomplished all of this with a limited number of staff while working out of her apartment in the midst of the pandemic, although she has always felt rather pleased with what she was able to achieve during a very difficult time.

6.2 The Inspiration

Sipa's concern with the extreme austerity and elevated femininity in Romania was one of the numerous cultural and historical factors she combined into her paintings (Nast & Vogue, 2020). In Bucharest, Sipa witnessed the fusion of French and other architectural styles, including grey brutalist residential complexes and giant communist monuments. She saw that the women, who normally take great care of their appearance, were dressing up for a trip to the grocery store and that they adored their newfound air of ultra-femininity. The designer's goal was to illustrate the '*contrast between heightened austerity and extreme tenderness*' that she saw in her native Romania by recycling a post-consumer waste cloth and using traditional lacemaking techniques. She did this by creating a garment out of the waste material.

Back in Bacău, Romania, the locals have always placed a high value on everything, from the most mundane things to the things that have been thrown away, and they have a habit of keeping these things for the long haul. Behind closed doors, even the smallest of goods is adored and endlessly repaired.

A majority of Sipa's artwork is focused on the creative ways in which her grandmother upcycled discarded items from around the house. Sipa's research evidences references that range from broken garden fences that her grandmother used for the ruffled clothes from her childhood. They are a manifestation of the innumerable colours that have developed in her work. Every time she met her grandmother, she noticed there was always something different around the house—something moved, something repainted. Her grandmother possessed the ability to transform even the most unremarkable objects into something very valuable.

6.3 The Collection

Alexandra Sipa is the inventor of the Romanian '*Camouflage*' Collection, which features abstract floral motifs and voluminous ruffles made from recycled electrical wires. The collection was made by Sipa to help lessen the annual e-waste total of 50 million tonnes. The United Nations predicts that by 2050, the amount of electrical waste thrown out annually could increase from its current 60 million tonnes to 120 million tonnes.

To construct the e-waste clothes, the designer modified the conventional method of bobbin lace, in which threads are wound onto elongated spools called bobbins for convenience in handling and twisting together.

Sipa's clothing reflects her commitment to sustainability and her belief that waste can be repurposed to inspire innovation and fresh approaches to old problems (Colossal, 2020). Her practice centres on making high-end goods from recycled materials, the electronic garbage that will amount to 50 million tonnes by 2022. Stunning pieces made out of repurposed electrical wires are evidence to how far Sipa has come in terms of how sustainable textiles are considered. Sipa made wire lace out of colourful coils and cables that she found in her collection of wires.

She learned to make the colourful lace through YouTube tutorials, books, and her own trial and error. The production of one of the designer's stunning outfits required a total of 1000 hours of work.

Sipa found it fascinating to see how customers would wear her experimental garments. She found it inspiring to see how someone with a keen eye for style would transform it to fit into their own closet.

The Collection also consisted of a vest with scalloped edges, a bustier with pink velvet straps, and two elaborate floor-length gowns both of which feature the colourful wires as a design element.

Another jacket in the collection was pieced together from tacky beach towels that were purchased at a thrift store in Bacău. A floral blouse that is part of the collection was created using fabric that was left over from the production of clothing.

6.4 Target Market

The designer intends for all of her outfits to be worn indefinitely on account of the growing concern for climate change. Further, the rising consumer demand for sustainable products have woken the business up to the need to take immediate action. Despite this, businesses need to be aware of the financial potential that exist within the cyclical fashion industry. It is no longer possible to overlook how important it is to consider the costs and benefits on numerous fronts, including the social, economic, and environmental levels. The fashion business needs to become more sustainable from the inside out, beginning with the materials used and all the way to the ethical treatment of people in the manufacturing chain and the compensation that they receive for their work. This holds true regardless of the materials being utilised.

6.5 The Challenge

The designer searched high and low throughout a recycling centre in London for the cables, steering clear of potentially harmful materials such as fibreglass.

When it came to the creation of the designs, Sipa found that there is even less room for error than there was before and she was unable to snip or untangle a finished piece and was required to exercise extreme caution at every stage of the process.

Because the wires were used in their natural state, Sipa had to take extra precautions to refine the garments so that they would have a smooth and comfortable fit.

It seems that finishing the items to a luxury grade was the most difficult part, and this was something that was different for each item. It was vital that it was both practical and aesthetically pleasing.

Sipa completed the entire bottom of the A-line lace dress as well as any loose wiring by employing an adapted version of the traditional Romanian technique of point lace, which resulted in a series of ornamental oval petals. The task at hand was to locate visually beautiful solutions to problems that needed to be solved functionally.

7 Case Study 2

Designer: Aniela Fidler Wieruszewska
Nationality: Polish
Founded: 2021
Primary Industry: Sustainable Textiles
Website: https://www.anielafidlerwieruszewska.com/

7.1 Background

Aniela spent her childhood in Poland, where she was exposed to a variety of creative outlets, including the work of her parents as graphic designers, her sister as a fashion designer, and her grandfather as a tailor. Her family has a long-standing tradition of having open minds, skilled hands, and ambitious hearts. Aniela earned her MA in Fashion Futures at the London College of Fashion (University of Arts London). In March of 2018, Aniela Fidler reached out to Hand & Lock for help with an experimental project that would see embroideries made from reused electrical cabling. Deezen Magazine and the Dutch Design Week have both featured her work, and she has received multiple awards in international design contests (Hitti, 2020). Also, her work has been shown during the Dutch Design Week. Dutch Design Week has also featured Aniela Fidler's work. Because her idea called for greener methods

to be used in the fashion industry, she was given the Kering, Alexander McQueen Award for Innovation. The reason we set out to learn more about her creative method was so that we could share it with you.

7.2 Artistic Ideology

The designer Aniela, who has a taste for the unusual, is deeply interested in the connections that can form between people and the things in their lives. Her studies cover a wide range of fields, from consumer behaviour and valuation theories to the impact of emotion on the appraisal of an object's durability. Aniela delves into the theories that describe how our hidden values, beliefs, and emotions are communicated through the clothes we choose to wear. Understanding what it means to be happy and how to achieve it, as well as how to create a future she can look forward to, is her primary objective. Her latest work explores how an object's emotional connection can influence its durability (https://handembroidery.com/aniela-fidler/, n.d.). Aniela explores the interconnections between the various elements of the stories we tell ourselves, such as places, people, emotions, objects, and substances.

7.3 Inspiration

Determined to change fashion's status quo, challenging questions are fundamental to Aniela's practice. Her stance really writes into the 2020 zeitgeist, but she has been stressing about issues in fashion long before it just became a trendy thing to do. Powerful narrative and strong sociological research are at the forefront of her work. Aniela is interested in fashion as a language and communication practice, and is intuitively drawn to explore other areas of design that have a similar function. She draws inspiration from the Polish School of Posters (especially from the period 1950s to 1980s.). She references the likes of Hilscher and Tomaszewski as a motivation for ways to communicate her ideas and finds them bold, witty, humorous, curious and imaginative, but most importantly, she considers them to be having an incredible power to make her think. She finds the use of metaphor in their work astonishing and finds them very suggestive and how very cleverly they create illusions.

Aniela has always been impressed with how artists from that period were able to express their personality and emotional involvement without distracting from the depth of the meaning of the message. She has always wanted to have the power to do so, but in the space of so-called 'fashion' by creating a critical commentary on society and subjects that she engages with.

The Polish abstract sense of humour and tendency to laugh at the absurdity of human behaviour are present in her during her thinking process. Aniela sees humour as a very powerful design tool, especially when it is used to comment on something

controversial otherwise. While growing up, Aniela was fascinated with the communication practices during then then called Polish People's Republic and how this critical humour from that period exposed the absurdities of the reality and expressed attitudes that did not fit the official discourse. Aniela believes that as a designer, she has a duty to trigger reflection and finds her Polish sense of humour as a guiding factor.

7.4 The Award

The Kering Award for Sustainable Fashion was co-created by Kering and the London College of Fashion's Centre for Sustainable Fashion. Each year, a student is recognised for their outstanding contribution to the field of eco-friendly fashion with this prize. Two separate companies within the Kering group will provide students with briefs outlining their requirements for a capstone project designed to solve a specific issue. Each year, a fresh brief is written. Aniela was a concept designer for Alexander McQueen and was greatly influenced by the label's innovative use of goldwork embroidery. McQueen's signature style is characterised by his deft blending of conservative and edgy elements. Because the issue of technological waste is becoming more pressing in the modern world, Aniela found the difference to be extremely astonishing. She wanted to help the Indian community learn the skills and knowledge it would take to address the issue of electrical waste by applying historical craft because of the growing awareness of climate change's effects and the issues it presents in both India and Poland (Wieruszewska, n.d.).

7.5 Scope

Because of the time and effort required, hand embroidery possesses many of the characteristics that promote sustainability. Despite this, numerous renowned fast fashion brands persistently market sequin and bead-adorned items at astonishingly low prices. Despite the fact that none of these steps can be automated and that they all need substantial human effort and knowledge, this is the case. For this reason, Aniela's work stands as an exemplar to show that more may be done, especially in terms of educating clients about the production process of embroidery. It seems impossible to believe that a sequined dress costing only seven pounds would be sold without someone else picking up the tab. It is important to implement simple recycling practices in the creation of polyester-based embellishments such as plastic beads and sequins. Thanks to technological progress, everyday materials can be replicated in a manner that is at par with or even better than the original. There are a plethora of commercial possibilities here.

8 Case Study 3

Designer: Elnaz Yazdani
Nationality: British
Founded: 2021
Primary Industry: Sustainable Textiles
Website: https://www.elnazyazdani.com/

8.1 Artistic Ideology

Elnaz Yazdani is a well-known artist who is known for her obsession with combining traditional embroidery techniques with non-traditional materials. In addition to her work as an embroidery instructor in the community and online, she also creates art. Elnaz gets her creative juices flowing when she thinks about industrial materials that have been repurposed and the ways in which she can embellish, connect, or otherwise transform these items using stitch.

8.2 Inspiration

The trips that Elnaz made to the scrap markets were inspiring for her as she let her imagination run wild with all of the unusual material and repurposed items they offered for sale. Not only does she highly recommend going there she also made it into a habit of carrying around a sketchbook with her, which she found very helpful.

Elnaz also learned from the experience of utilising different materials. When working with these materials, she frequently needed to reevaluate the way in which she taught traditional embroidery skills along with special workshops on '*Alternative Goldwork*' and '*Contemporary Goldwork*', both of which became and still are extremely popular (Elnaz Yazdani Embroidery, n.d.). These workshops reincarnated the age-old craft of goldwork by incorporating materials for embroidery that are unusual or unorthodox.

8.3 Recognition

In the year 2020, Elnaz won a recognition in the Embroiderers' Guild Beryl Dean Award for Teaching Excellence in Embroidery and Design. This award was presented to her by the organisation. In addition, the Embroiderers' Guild named her the 18–30 years Embroidery Scholar. She graduated from Manchester School of Art with a Bachelor of Arts (Honors) in Textiles in Practice degree and currently resides in Leeds, UK.

8.4 Work

Elnaz's degree programme was when she first started experimenting with unconventional materials and found objects. She was given a task that was titled 'The Alchemy of Cloth', and as a result, she developed an intense interest in alchemists and the process of material transmutation. Becoming obsessed with transforming the mundane into the extraordinary through the use of thread, led to the development of this idea. She frequently finds beauty and inspiration in a broad variety of unique materials, and she likes incorporating these elements into her stitching projects whenever she has the opportunity to do so.

Elnaz takes great pleasure in infusing the element of stitch into her work, whether she is working on large-scale paintings or modern jewelry pieces. This is true regardless of the medium that she is working in. She spends a considerable amount of time making embroidery-teaching samples for her pupils in the fields of costume, fashion, and textiles. These are subjects that she teaches.

The employment of unconventional materials is a reoccurring theme that appears throughout her body of work. Her work is an example of this motif. The materials that she chooses to acquire serve as the inspiration for each project that she undertakes; the colour and shape of these materials have an effect not only on the finished product but also on the method used to make it. She obtains waste offcuts from local industries and manufacturing businesses to add to her collection of materials, and she collects these materials from a wide variety of sources. She is always looking for new and unique supplies to add to her collection.

As Elnaz learns new embroidery techniques, her work evolves and frequently takes unexpected detours; thus, this has an impact on the classes that she teaches. The unorthodox materials that she collects change throughout time as well, based on the various types of waste that are made available. This is because she is an artist.

During the time that she was required to remain in isolation due to the epidemic, her obsession on unique and found objects only grew stronger. Elnaz was surprised to find that she had more time on her hands, which enabled her to research a variety of concepts and organise things that she had amassed over the years. Lockdown also urged her to look about her and find methods to recycle waste materials from her home, such as broken wires, game pieces, or outdated stationary, which she discovered. She found out about these things when Lockdown was helping her. She is able to escape her problems by immersing herself in her work, which is good for her mental health. After a long day of teaching online, she finds that getting lost in stitching allows her to unwind and relax. She does this by creating captivating embroidered worlds out of repurposed materials. This piece of work has evolved into an ongoing project for her, which she intends to display once life has returned to its usual state.

By collecting trash that is too little to be of any value and would otherwise be dumped in a landfill, she has developed a beneficial working relationship with a company that supplies components to vehicle makers. In addition to that, she makes excellent use of the local scrap store known as Scrap Stuff.

9 Conclusion

Although the fashion industry is making attempts to become more environmentally friendly, the rising demand from customers is now outpacing those efforts. This is the case despite the fact that the fashion industry is making efforts to become more environmentally friendly. The potential for long-term sustainability within the fashion industry has been hampered by a number of factors, including the industry's slowness or unwillingness to counteract consumer culture (more consumption), as well as the closely related output growth (more production), for the sake of economic reasons. The current estimates for the fashion industry presume that the economy will continue to grow indefinitely and that resource consumption would be limitless. On the other hand, models of unlimited expansion ignore the constraints that exist on the planet, such as scarce resources and the accumulation of trash from innovations or activities that cannot be maintained indefinitely. The global fashion industry sorely needs degrowth, which is usually described as a deliberate economic downturn accompanied by lower production volume. This is in contrast to the industry's current strategy of seeking endless growth, which in turn encourages practices that are not sustainable.

Despite this, it is necessary to consider cultural, psychological, and sociological factors while developing 'post-growth fashion' in response to degrowth in the sake of improving sustainability. For instance, even if the full range of the boundaries of a planet are established, it is still difficult to determine what exactly constitutes a fair share (Schaffner, 2020). In addition to this, due to the globalisation of the economy in the modern day, it might be difficult to precisely define what constitutes a 'share' for a particular nation or company. Some developing nations' economies and societies depend on textile and garment production; their collapse could result from degrowth. These countries would be forced to find alternative sources of employment. In addition, the fashion industry cannot bring about these changes on its own; rather, there must be a cultural shift away from viewing fashion as something that is vain and insignificant.

There is a cost to the environment associated with fast fashion, but this cost can be reduced if companies and industries switch to more environmentally friendly manufacturing practices. If degrowth policies are put into place to reduce production, and solid businesses committed to higher product quality, longer product lifetimes, and lower production volumes are formed, then it is possible that the industry will be able to reclaim its prior state of equilibrium. Extended producer responsibility can promote environmentally friendly corporate practices in a couple of different ways. One of these methods is by making waste an expense for industry, and the other is by encouraging it to avoid overproduction.

That is the logical conclusion to the whole situation. Promoting a CE, in which resources are kept in circulation within the system for as long as possible, is another technique for improving environmental sustainability. One strategy for doing so is limiting the expansion of the fashion industry. The onus of increasing the likelihood that a consumer will continue using a product is generally placed on the user by increasing the pleasure that can be derived from using the product and developing

stronger person-product attachments (Lemille, 2019). There are a number of different ways to increase the likelihood that a consumer will continue to use a product. However, to achieve longer product lifetimes, it is possible that it will be necessary to decouple the ownership of fashion from its use. Because of this, traditional profit baselines would need to be shifted from a one-time sale to one that is based on repeated use, and business models would also need to be shifted as a direct result of this.

Models of consumption based on access are one step toward circularity. Rental and peer-to-peer (P2P) sharing models are already in operation in the markets for formal, designer, and special-occasion clothing. However, many customers do not consider rentals to be a viable option as a viable alternative to fast fashion due to limitations in price, availability, and hygiene. These limitations prevent rentals from being a practical option. Because of the expansion of collaborative consumerism and the sharing economy in recent years, leasing and renting apparel has become increasingly popular. This trend has been especially visible among younger customers. It is anticipated that the total value of all transactions that take place within the sharing economy in Europe, which includes renting and exchanging, will amount to 28 billion euros. Consequently, a large number of companies, particularly those that focus on the high-end segment of the market, are investigating the viability of collaborative business models that include the mending and reselling of previously owned articles of clothing. However, the additional transportation efforts could potentially overshadow the environmental benefits that can be gained from collaborative consumption.

At the end of a garment's life cycle, there is an opportunity for the fashion industry to become more sustainable and circular by recycling the materials used to make the product. Both pre- and post-consumer textile waste can be recycled using a wide range of mechanical, chemical, and thermal methods. Recycling, on the other hand, is made more difficult by the fact that many modern garments are made of mixed fibres, which first need to be separated before they can be recycled. Thus, the technical requirements for sorting post-consumer trash are considerable, and are typically met by automated methods based on near-infrared technology due to the waste's heterogeneous makeup (Hysa et al., 2020). In addition, with an average accuracy of over 90%, robot technology has been able to sort four distinct types of textiles.

To generate new materials, the process of mechanical fibre recycling entails nothing more than shredding the waste from textile production into shorter fibres. Thus, the quality of the original fibres is degraded. It is possible to achieve a high percentage by using pre-consumer cotton waste and/or other virgin fibres. On the other hand, due to the fact that shredding causes a degradation in the fibres, it is recommended that no more than 20% of post-consumer mechanically recovered cotton fibres be blended with virgin cotton before the strength is guaranteed. This is because shredding causes fibres to become shorter and less uniform (which are longer). Following this step, the shredded fibre can be repurposed into new products that have a lower value on the market, such as composites, non-wovens, and fillers.

When compared to the effectiveness of other recycling processes, mechanical recycling is laughably inefficient. For instance, cellulose fibres can be recycled

through chemical recycling, which entails first dissolving the fibres chemically and then fractionating the resulting polymer into smaller pieces. Another method for recycling cellulose fibres is mechanical recycling, which involves shredding the fibres into smaller pieces. Because the fibres are retained better than in mechanical recycling, it is hoped that this technology will enable the production of clothes with a greater proportion of recovered fibres, hence increasing upcycling; even yarn made wholly from recycled materials can be produced. Polyester and other thermoplastics can be recycled using a thermal recycling technology. Recycled thermoplastic fibres undergo the same melt-spinning procedure as virgin thermoplastic fibres. Over the course of the past few years, recycled fabrics have made significant strides, and with the support of emerging technologies, they still have a great deal of room to grow. One procedure that falls within this category is known as the cellulose carbamate process. Utilised in the same ways as viscose (in non-wovens, wovens, and knits), or blended with other fibres, cotton-rich textile scraps can be transformed into staple fibres of the same quality using this method (such as cotton or polyester). The Ioncell-F method, for instance, involves breaking down cellulosic fibres into monomers before spinning them into a polymer. Fabrics made of 100% cotton or viscose may be used as a suitable substitute. Since Ioncell-F and cellulose carbamate rely on fibre-presorting technology, other chemical recycling systems have concentrated on mixed fabrics (such as polycotton) to enable unsortable recycling with cost-effective chemicals. This is done because polycotton may be recycled without being separated. This is done because the recycling process for polycotton fibres does not require the fibres to be sorted beforehand. Chemical treatments can also be used to eliminate pollutants from the environment, such as the hazardous substances found in discarded textiles.

The processing of virgin fibres may have more negative environmental effects than mechanical, chemical, and thermal recycling of textile materials. However, this conclusion is contingent on the characteristics of the recycling process. The amount of energy needed to recycle polyester is only 1.8% of the amount of energy needed to produce virgin fibres, while the amount of energy needed to recycle cotton is only 2.6% of the total energy needed to make new fibres. The percentage of recycled polyester on the market is just about 14%, while recycling rates for cotton are still very low. Because many textiles contain chemicals that cannot be recycled, or because it is physically impossible to recycle textiles because of the presence of indivisible fibre pieces, in some circumstances, incineration of textiles combined with energy recovery may be a more environmentally friendly option than recycling textiles. Therefore, promoting circularity demands innovative ways to the recycling of textiles. Prospective developments in waste management and recycling technologies may arise from a directive made by the European Union (EU) that all fabric and apparel waste be sorted, and processed in each of its Member States by the end of 2025. Further, all clothing items will be recovered and recycled back into the system after the policy of extended producer responsibility is implemented, thus completing the material loop. The acceptance of trash as an inevitable byproduct of the fashion industry shifts the industry's focus from rapid, ecologically damaging fashion towards slower, cleaner, more sustainable options. Both the design of clothing

of the future, which must be made to be recyclable, and the implementation of standard practices to close the material loop, both of which will require the textile industry to undergo structural adjustments. To further develop a sustainable fashion business, it is crucial to combine garment longevity and waste management into a thorough garment life cycle model. We refer to this framework as a 'life cycle' of a garment.

While the aforementioned reprocessing expertise can support and diminish textile and inventory waste, it is nevertheless vital to scrutinise whether the fashion system can be restructured to escape waste, particularly excess production or unwanted stock. Either a proactive (preventative, reducing) or reactive strategy can be utilised to successfully implement sustainable fashion practices and substantially cut down on garment waste (reuse, recycle and dispose). The transformation of the fashion industry has as one of its primary goals the reduction of waste before it even occurs. To accomplish this goal, new ways of thinking are required in all aspects of the industry, including retail, design, and manufacturing. A combination of preventative and responsive measures to cut down on waste and find new uses for the product to lengthen its lifespan would be an effective alternative that could be implemented. However, the strategy that is least sustainable is the one that is always reactive and is solely concerned with finding the most efficient way to get rid of the product. Any one of these strategies, when put into practice, will inevitably face a number of challenges.

When design departments and manufacturing facilities are geographically separated from one another, the likelihood of organisational waste increasing. For instance, if pattern cutters and designers are not aware of the exact width of the fabric that will be used in production, they will not be able to create designs that make the most efficient use of the material and generate the least amount of waste. Instead, it is the planner at the manufacturing company who is responsible for selecting the method that will be the most efficient in terms of reducing the production run. By providing instantaneous feedback on both the 3D model and the 2D pattern, more recent design software makes it easier to make the leap from concept to production. Although this software will not be able to get rid of all pre-consumer fabric waste, the possibility that it could serve as a feedback mechanism for fabric waste is fascinating and calls for further research.

If we question the established order of things in terms of fashion design and manufacturing, it is possible that there are more efficient ways to create clothing. To reduce the amount of fabric scraps thrown away during manufacturing, proactive techniques have been developed for garment design. Offcuts can be used in inventive ways to adorn the garment through design-led production or invisible remanufacturing, while visible remanufacturing involves placing fabrics in external, visible places. It has been determined that by utilising this cutting-edge methodology, a savings of up to 18% of virgin material and 7827 kg of carbon dioxide could be achieved when manufacturing 10,000 garments. By considering smaller offcuts, which can be reused in mechanical fibre recycling, one can expand the opportunities to save more fabric and reduce emissions. The implementation of cutting-edge production methods, such as the one outlined in this article, is one strategy that could

be used to moderate the damaging impression that the apparel industry has on the ecosystem. In a similar vein, if those in charge of design and production collaborated more closely, it might be possible to develop a model of sustainable design, production, and consumption that has a minimal impact on the environment.

Persistently high cost pressure and a high level of competitiveness, both of which make it difficult to alter business procedures, characterise the fashion industry. However, it is of the utmost importance that the entire industry (from the production of fibre to retail) take responsibility for the implications that their actions have on water, energy, chemical, CO2, and waste. However, to lessen and even reverse the effects of this, businesses will need to go through transformations, which is something that businesses are typically resistant to doing for a variety of reasons, the most important of which is financial. The textile industry, for instance, needs to immediately begin investing in cutting-edge pollution control technologies to get rid of chemicals, heavy metals, and other potentially hazardous elements found in waste streams. However, switching to manufacturing methods that are less harmful to the environment would result in an increase in production costs, and these increased costs would be passed on to customers. It is possible that this will mean the end of fast fashion and a decline in the overall economic health of the fashion industry.

Nevertheless, it is possible that production costs could be lowered by optimising industrial processes. This could involve lowering the amount of chemicals used in a process, for example, or providing economic incentives for businesses to adopt more environmentally friendly practices. In a similar vein, proactive design and inventive business models work together to lessen the impact of waste and overproduction and, ultimately, to secure a more secure economic climate. This Only by entirely abandoning the fast-fashion model, which would reduce both overproduction and overconsumption as well as a proportional drop in material throughput, can the fashion industry hope to thrive in the long run. Long-term fashion sustainability requires a total shift away from the fast-fashion business model. To adapt to these changes, businesses and consumers around the world need to work together and adopt fresh points of view. Think about renting, leasing, upgrading, repairing, and reselling as potential business models because they all contribute to longer product lifespans and a new, slower lifestyle for customers. These methods can also lead to eco-efficiency (through increased use, as in the case of renting) or self-sufficiency (via decreased use) (less consumption). However, policies that address the social, cultural, economic, and material organisation of consuming are needed to successfully influence consumer behaviour. The future of the garment industry lies on slow fashion. However, shifting to this model will require a fresh perspective on the whole system, as well as innovative thinking, teamwork, and compromise on the part of designers, producers, stakeholders, and customers. To make the change to a fashion industry that is kinder to the environment, we need new knowledge at the system level. In addition, a practical approach of recycling textiles must be created. One of the greatest difficulties in the future will be keeping up with the changing tastes of consumers and the expanding notion of what constitutes style. The adverse impact of the apparel industry on the ecosystem can be mitigated if consumers treat clothes more like a necessity than a luxury item and are ready to pay more for it.

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Aspiring Makers: Making a Living Without Hurting the Planet

Mukthy Sumangala and Chindu Treasa Benny

Abstract The practice of wearing jewellery to spiff up one's appearance has persisted for thousands of years. Recent studies have shown the utilisation of textile waste for jewellery that promotes environmental sustainability. This research aims to investigate potential opportunities for the market for eco-fashion jewellery on a broader scale. Additionally, the study focuses on the role of Indian-based eco-jewellery startups in developing innovative yet sustainable practices for the jewellery brands of India. The study also considers the initiatives taken by selected brands in the established market to increase sustainability awareness and make it more accessible, as well as the future prospects for this market niche; and finally, suggest a sustainable business model value proposition to promote eco fashion. The case studies here are constructed through in-depth interviews and facilitated dialogues with the founders of the chosen sustainable fashion jewellery firms. These businesses have devoted themselves to creating environmentally friendly products and have created sustainable solutions for a better planet.

Keywords Textile jewellery · Sustainable jewellery · Eco-fashion jewellery · Sustainopreneurship

1 Introduction

Jewellery has always been a component of human civilisation, even from the times when man first used tools and clothing some 100,000 years ago. Even the excavations at the Harappa and Mohenjadaro sites have uncovered an enormous quantity of beads in a wide range of materials and shapes used with gems and stones. Stone,

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animal skins, feathers, plants, bones, shells, and wood were all used to make jewels and semi-precious materials such as obsidian and semi-precious stones. Artists created modern jewellery designs as a result of evolving technologies over time.

2 Meaning and Significance of Jewellery

Each ornament represented the position and dignity of the wearer in some tribal societies and was also thought to possess some magical properties. Therefore, adornment served more than just the innate desire to adorn the body; it also acquired symbolic meaning. Amulets with prayers engraved on them to shield the wearer from negative forces are a vivid expression of this idea. All cultures and religions use this type of jewellery to ward off danger or to summon certain virtues.

Since the so-called jewel is no longer distinctive and reserved for the upper classes, jewellery making has been altered to match contemporary activities. The production of jewellery based on an original and inventive design is what is commonly referred to as modern jewellery. This procedure is also regarded as a kind of artistic expression because the creations' unparalleled prestige and strong position in the artistic community are a result of both their aesthetic and technical originality. Natural components such as shells, seeds, fibres, nuts, and dried fruits give ornamental items an instantly futuristic feel.

The use of materials and forms is becoming more innovative among new jewellery designers in response to consumer trends, giving each piece a distinctive personality by incorporating aspects from nature. To develop new designs and alter the idea of contemporary jewellery, sustainability efforts mostly concentrate on using natural elements, such as seeds, fibres, and materials.

3 Sustainability and Jewellery Business

The term 'sustainability' refers to the ecosystem's total resilience rather than simply the operational management techniques. As a result of the existing gap—caused, as we all know, by the limited resources and insatiable human desire—and the increased scarcity of resources, consumers throughout the world are increasingly interested in the sustainability of the environment and its resources.

The creation of traditional jewellery has a significant negative impact on the environment due to its high carbon footprint. Sustainable development, as described by the United Nations, is 'filling the demands of the present without compromising the needs of the future generation'. UN Sustainable Development Goals adopted in 2015 also highlights that 'the triple planetary problems of pollution, biodiversity loss, and climate change are all the results of unsustainable consumption and production systems. People should take advantage of the chance to collaborate to increase resource efficiency, lessen waste and pollution, and create a new circular

economy since changing our relationship with environment is essential to a sustainable future'. Sustainability has an impact on micro levels as well, such as fashion jewellery accessories, and is not just limited to macro ones like architecture, construction materials, and lumber. The aspiring designer's group might adopt and promote this idea of sustainability to explore new options, vary their grasp of the theme, and think beyond the box.

There are various methods to address the idea of sustainability in jewellery, including:

1. Giving the jewellery a second chance at life and new significance through recycling. This could be done in a number of ways, including wearing it in a different way than before, melting it down, adding to it, altering it, casting it in another material, etc.
2. Making jewellery out of various waste items.
3. Ephemeral jewellery receives the highest rating in sustainability rankings among the new category because it requires no raw resources to create.
4. To make worn-out jewellery wearable, certain modifications can be done to it. Every product experiences wear and tear; for example, wool begins to pill, fabric thins or gets threadbare, acids or skin perspiration can cause metal jewellery to rust and silver jewellery to tarnish in an instant.
5. Jewellery is fashioned from materials found in nature, such as fruit seeds, bones, stones, flowers, leaves, feathers, shells, etc. Working with organic materials might evoke the use of prehistoric and primordial materials.

4 Sustainopreneurship in Jewellery Business

Sustainability has rightly become a hot topic in the jewellery industry. It has inspired sustainable and ethical jewellery brands to launch new initiatives, share more information with their customers, and set new targets to do better. The global jewellery market is expected to grow at a compound annual growth rate of 8.5% from 2022 to 2030 to reach USD518 billion by 2030. Like apparel, there is a growing movement towards the ethical sourcing and production of jewellery. As per the study conducted by Matter of Forum, the millennial generation, that favours goods and companies with a conscience, makes ethical openness in the manufacturing of jewellery particularly important today. According to a recent survey, over 80% of buyers prefer conflict-free, ecologically friendly, and safe jewellery, proving that the 4 Cs are no longer sufficient. Millennials want to be sure that the products they purchase have not had a detrimental influence on people or the environment.

The authors of this study attempted to investigate 'sustainopreneurship', a novel approach that has recently gained enormous popularity among new-age jewellery businesses. The term 'sustainopreneurship' was first used in 2000; papers on the subject followed in 2003; further development and a proposed definition appeared in 2006. Abrahamson (2007) highlights consumers and businesses alike have been

impacted by the increased behaviour toward the manufacture of sustainable products brought about by the contemporary knowledge of ecological balances and environmental conservation. As a result of the expansion of ethical culture (Shaw et al., 2006), companies now have a greater awareness of their ethical obligations as well as of the environment and sustainable resources in which they operate—and so assuring the sustainability of not just the manufacturing process but also the products produced, the individuals responsible for it, and the workplace.

Within the framework of the triple bottom line (Elkington, 1997), the authors of this study will concentrate on sustainable business solutions and their effects on the organisation. This should lead to the identification of the factors underlying the idea of sustainopreneurship among socially and ethically responsible business owners in the eco-jewellery sector. The research will be based on case studies of Indian sustainable jewellery firms that have had success developing sustainable solutions in the field of slow fashion.

5 Methodology

To further comprehend the subject, empirical data for this work was gathered using a qualitative methodology. Numerous conversations with company founders, consultants, and organisations were conducted in person. The choice of individuals was made with consideration for their various backgrounds and expertise in the field of eco-friendly fashion jewellery design and the creative sector, with a focus on the sustainable jewellery segment. The case method was employed by the authors to write this paper. Case study research shines at helping us grasp a difficult problem or topic, extending our knowledge or strengthening what is already understood as a result of prior research. Through this case study, the authors tried to emphasise a detailed contextual analysis of successful eco-fashion jewellery business models and their contribution to ethical business.

5.1 Objectives of the Study

The primary objective of this study is to examine the different opportunities associated with the eco-friendly fashion jewellery market. Second is to understand the business model practised by eco-jewellery startups in India. Third is to consider the steps taken by successful Indian startups in the established market to promote sustainability and make it more accessible, as well as the potential growth of this market segment; and finally, to propose a value proposition for a sustainable business strategy to support eco-friendly fashion.

5.2 Results

This study has concentrated on Indian jewellery manufacturers that have developed long-lasting solutions to the never-ending landfill issues. In this section of the study, the authors have used thematic analysis to examine the findings of the in-depth interview transcripts. Based on the most commonly used or highlighted keywords, each case has been separated into many categories.

5.2.1 Case 1: Suta Bombay

Suta, the brainchild of sisters Sujata (Su) and Tanya (Ta), aims to preserve India's rich artisanal heritage by fusing traditional arts with contemporary design. Their approach has ensured that these crafts resonate with modern audiences, allowing them to provide a sustainable livelihood to thousands of craftspeople across the country. Suta's earliest products were mul sarees, inspired by the soft cotton sarees that women can wear daily. They were encouraged to transform how sarees are perceived—from cumbersome occasion wear to wardrobe staples that can, just as quickly, be worn to grocery runs as to corporate boardrooms.

Suta is built on values that transcend the products themselves—this is reflected in their communication, be it the short stories accompanying each product or the visual imagery they use to advertise the brand. At Suta, they have built a community of like-minded people who have supported them every step and profoundly love and admire them. All of these come together to form Suta (Fig. 1).

As individuals or co-founders, sustainability has always been at the heart of everything Sujata and Taniya do. They compost the kitchen waste, make and use bio-enzyme in place of commercial cleaners, and even have vegetable gardens. Sustainability is not just an ideal but a living, breathing practice at Suta, which finds resonance in various initiatives, including Suta Relove for buying and selling pre-loved Suta products, and Suta Earth to reuse old sarees and help reduce textile waste.

Fig. 1 Ms. Sujata and Ms. Taniya, founders of Suta. (https://www.instagram.com/p/CsMB2tjKiYK/?igshid=NTc4MTIwNjQ2YQ==)

Suta's business incorporates several initiatives to bring them closer towards the ideals of a circular fashion cycle and fair trade.

Suta Garage At Suta, they are very mindful of waste and, to an extent, they repair and refurbish existing items to extend their lifecycles and use. They have carried forward this line of thought with Suta Garage, a brand-new category and initiative launched on the website. Suta Garage allows customers to purchase sarees, blouses, dresses, loungewear, accessories, menswear and home furnishings at rebated prices. That is because the products listed in this category have minor defects that prevent the items from passing stringent quality checks, although relatively unnoticeable. Instead of discarding these products, they seek to prevent them from ending up in landfills and give them a new life with this initiative.

Upcycling Giving a product, or even parts of a product, a new life without degrading the original value is the essence of upcycling. Suta has launched several collections comprising upcycled products, such as Gudiya, which had dolls stuffed with salvaged fabric scraps from our production processes.

Suta Earth another initiative based on upcycling encourages customers to be more eco-conscious. Customers can save up to 50% on their future Suta purchases by sending their old sarees that they are not using anymore. These sarees do not necessarily have to be Suta sarees. The old sarees are upcycled and used as packaging bags. Suta's recently launched bags are named after cities where they made using bits and scraps from their fabrics. Upcycled patchwork tote bags are a customer favourite and an excellent way for Suta, as a brand, to be mindful of environmental impact.

Suta Relove This initiative gives their customers a platform to sell their preloved Suta products. Again, they are offering customers a chance to extend the lifecycle of these garments and thus save them from ending up in landfills.

The Indian handicraft market has traditionally been unorganised, with intermediaries and brokers dominating what weavers can make and how much they earn. This proved to be a challenge for them, too, while starting. They have to work hard and demonstrate their commitment repeatedly to weavers, who were initially reluctant about trusting them and coming on board. During the pandemic, the weaver community was affected by cancelled orders and a lot of dead stock. Suta bought this stock to help them and encouraged their customers to purchase these products. Today, Suta work with 17,000 weavers and keep adding to this number. Many of their artisans are women for whom working with Suta is their first tryst with financial independence. Instead of handing over their salaries to the male members of their households, they helped them set up bank accounts and take control of their finances. This a small but necessary step towards empowering women. They also give a lot of flexibility for women to work from home.

Suta majorly follows a direct-to-consumer, or D2C e-commerce, business model. D2C e-commerce is when the manufacturer or producer sells directly to consumers

from their web store. The D2C e-commerce model helps them to, quite literally, cut out the middleman. One of the most significant advantages of a D2C e-commerce strategy is that they get complete control of all activities, from designing and packaging to marketing. It also helps them to create an omnichannel experience for customers. They also liaise directly with artisan clusters in various parts of the country and engage directly with them to ensure that they receive the maximum value for their work without the interference of brokers or mediators. Suta also sells via marketplaces such as Myntra, Ajio, Amazon and Nykaa Fashion.

Along with these, they have three retail stores in Mumbai and Kolkata. Suta's flagship store is launching in Bangalore. They also have a few shop-in-shop models.

Suta is associated with 17,000 weavers and artisans and works with weaver clusters across Odisha, Jharkhand, West Bengal Jaipur, Tamil Nadu, Andhra Pradesh Banaras and Lucknow and Kashmir. Women form a significant part of the weaver clusters. Even their supporting staff members who work in corporate offices are predominantly women.

Suta actively engages with their weaver clusters to better understand their pain points and ensure their meaningful and sustainable association with them. They have also undertaken numerous measures to help improve their quality of life and enable more social equity for them. They also try to work with sustainable fabrics as much as possible and include products woven on handlooms, allowing them to associate with smaller weavers and reduce environmental impact. In terms of profitability, they believe in keeping costs low, being as frugal as possible (within reason) and investing in people and processes that will ensure lasting gains.

They started Suta with a desire to make a change and uplift the weaver and artisan community. They have always strived to keep this goal at the heart of all their endeavours. Suta pays the weavers and artisans fair wages for their efforts and gives them work all year round. Also, they have opened bank accounts for the women employed to provide them financial independence. They contribute towards the maintenance of schools where our weavers are based.

One of the biggest policy initiatives by the Indian government aims to enhance the credit off-take to in the MSME sector and individual entrepreneurs are the 59 minutes Public Sector Banks (PSB) loan scheme. Suta has taken a loan from a PSU bank to accelerate their business through this scheme.

The target market of Suta is men and women who are comfortable in their skin and value design over comfort. They target people who can make their own decisions. Suta is now getting opportunities to expand to international markets and currently ships to the US, the UK, Australia, UAE, Singapore, Canada and Bangladesh.

5.2.2 Case 2: Tejal Keyur Textiles

Tejal Keyur Textiles, a label started by NID graduate Tejal Keyur, takes up cycling to a new perspective with her designs. Growing up in Maharashtra, Tejal uses an unconventional way of reusing old sarees. Every design she makes has a story from her Vincent Van Gogh-inspired bags, indoor pot covers, and floor rugs. Tejal has

Fig. 2 Textile scrap bags by Tejal Keyur. (https://www.instagram.com/p/CrnAVz0ofJ4/)

been observing her parents create products out of everyday objects. They would mend, repair, make some changes to the existing structure and use the object to its fullest. Her venture reflects all the conscious choices that her parents made and continue to make. It is a challenge to find meaning or visualise a new form out of a lifeless pile of objects which have been discarded and reimagine their second life. Her venture reflects all the conscious choices that her parents made and continue to make. It is a challenge to find meaning or visualise a new form out of a lifeless pile of objects which have been discarded and reimagine their second life. Her target market is consumers with conscious choices and who appreciate the efforts made in the process of upcycling. Moreover, they are getting collaboration opportunities from international brands (Fig. 2).

The primary aim of Tejal Keyur Textiles is to upcycle the maximum possible amount of textile waste (currently focusing on sarees) into aesthetically appealing, durable fashion and lifestyle products, so they do not let them end up in landfills. Tejalkeyur uses the handknitting technique for upcycling, allowing them to fit a large volume of fabric into a compact surface (e.g. a decent-sized envelope bag requires fabric length equivalent to three sarees). This way, they have upcycled many discarded synthetic sarees into fashion bags in a shorter period.

The focus is on the following points to make their practices sustainable.

1. Use of discarded, surplus and unsold sarees to craft the products. Tejal focuses more on synthetics since they are too challenging to decompose and can hardly be used for other purposes.
2. Connecting and building a network of local communities for the sourcing of discarded textiles so that both the parties benefit and the age-old tradition; moreover, focusing on activity specific to a community (Bohareens—a community of women who collect discarded clothes).
3. Using hands-on techniques to craft the products for a lesser carbon footprint and employing a group of local women.

This business model consists of three elements:

1. Local sourcing of raw materials
2. Incorporation of hand-on-techniques for upcycling, with no machine involvement
3. Making use of local skills/training the women in a particular craft to perfection

This venture is self-funded, and they are working with eight women from her hometown. They have been training them for a year and getting their products made locally. From a local community named Bohareens, mostly found in Maharashtra, they collect discarded clothes door to door in exchange for utensils and other smaller domestic items. They help them collect the discarded sarees. They provide employment opportunities to a group of women who work from their houses once they finish household chores and let the team of women work from home since they hail from the rural part of the district and are not supposed to step out of their homes for work as per their family tradition. Also, this label held a training programme and started working with them, making them feel 'important' and 'capable' of making their own money. Also, a part of the sarees they cannot use for knitting is shared with another group of women who are financially weak and need work to fulfil their basic needs. Excess suitable materials are provided free of cost, and they make packing bags and supply them to bakeries and clothing stores. Also, they occasionally organise clothes collection drives in Kolhapur and Pune. Sarees with minor defects donated to orphanages and differently-abled people. Their contribution to the planet is by procuring synthetic sarees to upcycle so that at least a certain number of sarees do not get burnt in the dumping sights emitting harmful fumes and the residues of the same lead to soil pollution. The synthetic sarees are durable and do not decompose for years, creating blockages in water systems.

Furthermore, for them, sustainability and aesthetic values go hand in hand. They visualise the saree waste into new surfaces using a specific visual language. The niche customers who choose upcycled products as a fashion statement love the products thus made.

Tejal thinks consistency is the key here in a slow fashion and she would continue to do this work with clear conscience and would be experimenting with a diverse set of raw materials.

5.2.3 Case 3: Kalavai by Chindu

Kalavai is the creative edge of Chindu; an engineer turned designer who always had a leaning towards fashion and crafts from an early age. After her post-graduation in fashion management from NIFT and working for some years as a designer, she found her true calling in creating eco-friendly accessories. Her label preserves flowers and ferns around us in resin. The practice of resin is not new, either, but the uniqueness of crafting makes it different. Chindu's label Kalavai meaning assorted/melange in Tamil is an ode to nature's finesse by meticulously fossilising organic bits in biodegradable resin. Mother nature's gifts spurred her imagination to bring out the best in her artistic sensibilities.

Fig. 3 Dried flowers jewellery by Kalavai. (https://www.instagram.com/p/CiCkawzu9I4/)

Upcycling or repurposing is not just for clothing; everything can be transformed into something valuable. Likewise, with her label, she chose the fallen flowers, withered leaves, and mosses around her. The resin jewellery flowers are usually picked up from road verges and mountain ranges for lichens and wildflowers, and some exotic flowers are generally imported (Fig. 3).

The process includes pouring bio-degradable resin on a handcrafted frame and arranging the flowers aesthetically. Depending on the frame chosen, it would take 5–6 days to finish a product. Thus the withered flowers are restored with value. Under her label, along with flowers, Chindu is also mastered in preserving DNA jewellery. It is a beautiful way of keeping a baby's first coil, umbilical cord or even pet's fur.

The uniqueness of her brand is that all the accessories are entirely handcrafted with a traditional Indian accent of antique finish. She primarily focuses on the emotional selling point, as all the flowers have meaning according to the language of Floriography. Nowadays, everyone loves to give thoughtful gifts over expensive gifts. Her product line includes accessories- necklaces, earrings, bracelets and home decor. Thus, her entire line cherishes the florals around us, opening new possibilities for jewellery design.

5.2.4 Case 4: Dairies of Nomad

India-based sustainable Indian designer company Diaries of Nomad, which Harshita Gautam founded in 2013, offers silver and textile jewellery collection named Makutu. Makutu, which means 'magic' in Maori, is an eco-friendly fabric made from scrap fabrics used in Nomad's designs. They provide necklaces, earrings, anklets, bracelets, and brooches in their jewellery collection. All of the jewellery is hand created in their studio and has a bohemian aesthetic. The jewellery has a bohemian aesthetic and fits the brand's nomad vibe. She saw a gypsy while on the Pune-Mumbai highway. Attracted to her appearance and attire, she followed her home,

giving birth to Nomad and the ghagra, a free-size bohemian skirt. She eventually started producing more clothing, which caused the brand's waste to increase. So they began making jewellery under the Makutu brand out of recycled materials.

By reusing waste materials from the clothing industry, the women craftsmen from Harijan Basti create delicate, gorgeous, and fully handcrafted textile jewellery at Nomad (Fig. 4).

Nomad is adamant about paying its internal staff fairly and using fair trade practices for its outbound logistics. In terms of working hours, equal pay for equal effort, no additional work pressure, and understanding of human emergencies, they have built an open environment for in-house teams. They have also worked with NGOs to empower the women of the nearby tribal villages to become skilled artisans and trailblazers. Nomad has taken great care to ensure that the in-bound logistic traders from whom it purchases its raw materials have the necessary certifications for their sources of sustainable practices.

Dr. Brismar created the term 'circular fashion' in 2014 and connects it to sustainable development and the circular economy through the lens of the fashion industry. Circular fashion was defined as 'clothes, shoes, or accessories that are designed, sourced, produced, and given with the intention to be used and circulated the responsibly and effectively in society for as long as possible in their most valuable form, and hereafter return safely to the biosphere when no longer of humen use' (Dr Anna Brismar, 2017; circularfashion.com). This idea is firmly supported by Nomad, which also incorporates circular fashion into the design of all of its items.

To create accessories and other items for home décor that are inspired by nature, Nomad uses textiles that were left over from the creation of garments after being

Fig. 4 Hair accessory made of left-over fabrics. (https://www.diariesofnomad.com/products/sarod-red-flower-gajra)

cut, stitched, or defective. By utilising this fabric, they help to prevent about 18% of the total amount of cloth from going to the landfill each day. Their transition to a zero-waste production facility is being aided by this approach. Nomad have also started promoting 'slow-fashion' as a trend and promote the idea of repeating the apparel and accessories including silver and textile multiple times in different looks and style.

5.2.5 Case 5: Pure Ghee Designs

Pure Ghee is known for its quirky designs and eco-friendly accessories made of cloth. Launched by Aditi Prakash, a design graduate from NID, the brand has textile handbags as its forte (Fig. 5).

The product categories of Pureghee are bags, jewellery, hair accessories and home decor. They provide women with a range of products to express their individuality using accessories that are unapologetically Indian. Pureghee's handbags come with a unique element—handcrafted wooden parrots (Pureghee's signature element). Aditi strongly believes her label's USP is the workforce and 80% of the staff are women handling administration, handwork and stitching. When they joined, they lacked skill or had no skill set, but eventually, they learned from each other and formed a community. In their focus on reducing waste, all pre and post-production fabric wastes are upcycled to create unique colour bags. Her Katran frame clutch bag is made of fabric leftovers, where the women sort the fabric colour-wise and shred them to develop beautiful clutches and handbags. The brand

Fig. 5 Textile Gajra. (https://www.puregheedesigns.com/collections/gajras/products/maroon-genda-gajra)

associates with leather artisans to make a difference and uniqueness in the way zips are attached, the edges and the overall finishing.

Apart from vivid brocade handbags, their hair accessories are one of a kind. The collection includes mogra gajra (jasmine flower), strung together in a tie-up and styled on one's hair and Gendaphool, to mention a few.

At Pureghee, they engage with their customers to create awareness about the process and what goes into making their products. For customers, it may mean that they choose products that are a trifle more expensive but have been handcrafted with care. For them, it means they can pay their team fair wages and run a sustainable and equitable business.

5.3 Discussion

As part of the objective to explore the sustainability and triple bottom line parameters followed by the eco-jewellery segment, which is being discussed in this segment. Most of the prominent parameters that corporate and consumers shift to ethically conscious purchases were planet, people and profit parameters.

As per the study, selected eco-jewellery brands, which creates less or no impact on environment, minimal carbon footprint with reusable raw materials, have always been great pioneers in expanding its framework, which is mainly of sustainable and traditional basis to taking account of their ecological, social and financial performance. These brands are highly influenced by all who are directly or indirectly part of brand, especially in terms of sustainable actions of the firms, i.e. up-cycling, recycling, slow-fashion, etc.

5.4 People

Complex supply chains, excessive consumption, economic growth, environmental concerns, and social concerns are currently problems related to unethical and unsustainable jewellery, just like they are with fast fashion apparel. The fashion jewellery sector is predicted to have 1.6 million injuries by 2030 as a result of poor worker care. As a result, the fashion jewellery business is regarded as one of the most brand-centric sectors, with profit always taking precedence over long-term investments. The business has changed from being linear to becoming circular as a result of this issue. The case studies in this study have highlighted the solutions to these problems, which involve giving care, remuneration, equal rights, and recognition to their workforce to produce lasting solutions. As fair trade start-ups, they make sure that they collaborate with social security-eligible government-certified manufacturers and producers.

Additionally, there are 20 million people employed in the fashion jewellery sector, with more than 60% of these individuals being women who work in the

industry. Growing consumer demand for quick fashion has resulted in careless workplace practices such as child labour, sexism, unfair trade, unsafe living conditions, and unequal pay for women. To solve this issue once and for all, we must adopt a slow-fashion philosophy and educate both consumers and businesses about its core causes.

5.5 Planet

Since the turn of the century, the fashion and jewellery industries have been introducing dangerous pollutants to the air, dumping production and consumer waste in landfills, and adding poisonous chemicals to water bodies and landfills. As a result, a number of movements have emerged to educate businesses and consumers about their practices. Greener supply chains, eco-friendly dyes and fabrics, recycling production waste, and increased usage of organic materials are some of the sustainable solutions that have been put into practice to address the issue. Making everyone more ethically aware across the whole product development process—from acquiring raw materials to product design to final product manufacture to selling and beyond—is imperative at the moment.

Some of the environmental concerned suggestions brands initiated in eco-jewellery segments are:

- Good design that utilises all available resources in a sustainable manner
- Provides functional solutions for customers and does not create waste
- Transparency in supply since customers deserve to know how their accessories are made
- Easy and convenient, customisable slow fashion

5.6 Profit

These brands plough back their profit to meet their social objectives (reviving ailing craft units). Following sustainable framework these brands made huge positive impact in its artisans and great economic benefits to the people as well as putting the community on the sustainable map. These brands follow TBL (triple bottom line) approach where it is not just cited as the simply traditional corporate accounting profit plus social environmental impact unless the profit of the other entities is included as social benefits.

6 Conclusion and Implication

It can be motivating for large corporations to switch up their market segmentation, alter their supply chains, collaborate with new or established businesses, and set higher standards. Genuine commitment from the very top of the organisation is the most powerful motivator for any firm to progress toward sustainability. This has been proven in this study as all the brands have highly committed, environmentally responsible and ethically conscious jewellery producers. The values of the owners of the respective brands are what have built the foundation of their business models and allowed them to be recognised as sustainable eco-jewellery brands in India. Brands like these have been able to introduce innovations such as green supply chain, equitable pay, a content internal workforce, greener products, conscientious consumers, and zero-waste production facilities, all of which are the solution to our planet's impending demise.

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Sustainable Approaches in Design & Development of Athleisure

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Abstract The sportswear segment, particularly athleisure, has witnessed an upsurge and become crucial component of mainstream market owing to health and fitness consciousness among millennials and Generation Z. High performance fibres such as coolmax, micro denier, hollow fibres, polyester of varying cross-sections and smart materials, namely phase change materials and shape memory polymers are extensively utilised to meet the basic and desirable properties of dry feel next to wearer skin, rapid moisture transportation and wearer comfort in sportswear. However, like any other clothing segment, there is an ardent need to incorporate sustainable principles in design and development of sports clothing to avert deleterious environmental impact on account of massive production of sports collection. A range of sustainable fibres, namely bamboo, hemp, soyabean, etc. and recycled materials are explored for their potential and suitability for sportswear design and development. Clothing intended for professional training as well as leisure activities are designed utilising sustainable raw materials along with incorporation of innovative concepts of layering, asymmetrical styling, elaborate patch work, strategic positioning of eco-friendly labels and trimmings. A myriad of sportswear designers such as Decathlon, Satva, Stretchery, Deivee, Pact, Etiko and Tentree are trailblazers in launching sustainable sportswear ensemble. The chapter highlights the sustainable approaches adopted by various sportswear brand.

Keywords Athleisure · Brands · Fibres · Recycling · Smart materials · Sportswear · Sustainable

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1 Introduction

Textile industry is the backbone of the country with significant contribution to innumerous employment opportunities and country's economic development. Apart from traditional textile processes, the technical textiles also offer several pathbreaking career avenues and growth opportunities for country's youth and unemployed workforce. Sportswear and wearable electronics constitute an indispensable segment of technical textiles. Consequently, the aforesaid domain has witnessed tremendous innovations and has emerged as one of the most promising avenues for further research exploration. Furthermore, designers, manufacturer and retailers have been joining hands to launch design collections intended for tech savvy and fitness buff consumers who aspire for functionality, aesthetics and smart features in their ensembles. The sportswear is being designed and developed with integration of sensors and electronic components to impart comfort, sport specific functionality along with smart features such as activity tracking and monitoring of wearer's physiological parameters. Accordingly, several innovative approaches in raw material selection to ergonomics and design features have been experimented and incorporated to develop state-of-the-art smart sportswear. The enhanced and multitude of functionalities are possible with integration of electronics and utilisation of computing technologies in sportswear.

Sportswear is a crucial clothing category popular among sportsperson and fitness freaks that finds application in professional sports, athletics and leisure activities. Sports-specific clothing fulfill the wearer's requirements for comfort, dry feel next to skin, safety and protection from external elements. The classification and requirements of sportswear vary as per the sportsman's level of physical activity, ambient conditions and specific sport. Accordingly, the sports and fitness aficionados prefer including active wear, leisurewear and athleisure in their closets. The unconventional and latest sportswear is often designed and tailored to offer functional, aesthetic and smart features in one ensemble meeting all the stated expectations of consumers.

Athleisure is another key and captivating trend in sports arena with perfect amalgamation of fashion, cultural and urban lifestyle, thereby presenting a sporty, quirky sports ensemble.

2 Characteristics of Sportswear & Athleisure

Sportswear demands various performance characteristics depending on multitude of factors; however, generalised performance features for any sportswear irrespective of type of sports include thermo-physiological and psychological comfort, light weight, agility to wearer, fit, stretchability and easy-care properties.

The requirements for sportswear are generally based on a number of factors enlisted below:

(a) Sport type – team or individual sport/ professional or amateur sport
(b) Level of physical activity – active/ passive
(c) Ambient conditions – indoor/outdoor sport
(d) Specific functionality – wind proofing, antimicrobial etc.

2.1 Innovative Wearable Sensors & AI-Based Technologies for Sportswear

Designer brands and renowned clothing manufacturers are collaborating with foremost technological giants for the development of innovative wearables based on smart technologies. A gamut of trailblazing smart technologies in apparels and accessories which might have been fantasy a few decades ago are taking the fashion arena by storm.

A smart illuminating or colour changing sportswear as the sportsperson is exposed to varying ambient conditions, a clothing displaying real-time text messages or emoticons based on wearer's state of mind or a sensor embedded sportswear to monitor heartbeat and pulse rate are some mind-boggling innovations in smart sportswear.

Sports clothing with built-in sensors leverage clothing as sensing substrate and can revolutionise the wearers behaviour by serving as activity tracker and recorder of wearer's vital body parameters. The most crucial requirement in sensor-integrated sportswear apart from comfort and aesthetic aspects is inconspicuous integration of sensing elements and portable power sources into clothing which do not contribute to additional bulk in clothing or impair the wearer's flexibility.

3 Smart Sportswear for Health & Well-Being Monitoring

Figure 1 shows smart sportswear to monitor sportsperson's physiological parameters.

The unique and smart features offered by smart sportswear make them suitable for a range of performance and functional-based applications as enlisted below:

3.1 Performance and Data Analysis

An important aspect of sportswear encompasses maximising human performance, improving and monitoring sportsperson's performance. Watches or strap bands equipped with sensors are capable of recording a range of wearer's physiological data such as distance covered, steps taken, calories burnt, speed of the activity and body temperature, etc. The integrated sensors in the wearer's clothing are capable of

Fig. 1 Smart sportswear to monitor sportsperson's physiological parameters

monitoring health related parameters and in turn recording temperature, sweat and muscle movement and even the athlete's emotional response. The real time data recorded can be viewed or even retrieved for later use to track a sportsperson's performance. The data can be systematically analysed to guide the sportsperson to improve and work on their technique, fitness level and even to avoid injuries.

3.2 Health Monitoring

The smart sportswear ensemble is increasingly being incorporated with sensors exhibiting the capability of measuring body functions and biomechanics such as heart rate, breathing, lung capacity and perspiration or the muscle and joint movement. Smart sportswear so designed with integrated sensors can portray several salient and smart features such as timely monitoring of any health ailment, reduction or elimination of injuries and prediction of injuries beforehand as a result of Artificial Intelligence-based analytics.

Nike's Adapt: Nike has been the trailblazer in designing smart sports footwear that can electronically adjust according to the shape of wearer's feet.

Under Armour's smart shoe: The shoe uses record Sensor™ technology to connect to the smartphone app, MapMyRun. The app tracks the running course of a runner and reports data related to cadence, stride length, and distance travelled.

Polar heart rate sensor: Polar H10 heart rate sensor integrated in soft textile strap can effectively measure heart rate and connect heart rate to a wide variety of training devices via Bluetooth.

En Route jackets with embedded sensors are capable of keeping the wearer warm by automatic adjustment of temperature based on the ambient conditions.

Another unique technology adopts the use of intelligent textiles to help performers monitor their activities. A mini data cell is placed in a protective pocket, in the back of a sportsperson's base layer garment. A series of electrodes are woven into the fabric along with sensors. The cell transmits wireless signals and information regarding the performances of a player to a distant computer. This technology has been adopted in sportswear of football players allowing the coach to monitor each and every movement, heartbeat, and make comparisons.

CAD enabled three-dimensional measurement of body statistics offers customised fit for sportswear. Sportsperson's virtual fit is utilised for creation and adjustment of digital prototypes of sportswear. Virtual models exhibiting dynamic activities simulating the actual activity performed by sportsperson such as jogging, cycling, and skating are used to analyse the movements and performance of the sportswear.

Ambiotex's smart shirt intended for athletes is designed with integrated sensors and clip-on box to record the athlete's data pertaining to heart rate variability, threshold, fitness and stress levels.

A smart shirt laced with Bluetooth smart sensor can be paired with fitness apps such as MapMyRun, Runkeeper and Strava to capture the real-time data and monitor physical activity and physiological parameters of sportspersons such as intensity and recovery, consumed calories, fatigue level and sleep patterns.

Hexoskin smart sportswears are designed with embedded textile sensors to monitor cardiac, respiratory phenomenon, physical training, sleep patterns, and mundane activities of an individual involved in rigorous sports. The visualisation, reporting and analysis of data becomes very convenient with Hexoskin as the smart clothing is equipped with an accelerometer to quantify body movements, track heart rate to be viewed in real time. Furthermore, it prevents the sportsperson from over training by determining lung capacity for each activities performed and measurement of stress and training fatigue.

Wearable X, pioneer in bringing design and technology together, launched smart yoga wear incorporating haptic feedback. Posture monitoring and vibrational reaction by smart garment assists in guided yoga.

Vitali smart bra is another state-of-the-art smart sportswear designed for fitness freak females. The bra is equipped with sensors to track heart and breathing rates. The stress levels of women can be monitored via data collected from sensors, thereby sending a reminder to the wearer to take deep breaths upon detection of high stress levels.

4 Sustainable Approaches in Sportswear Design & Development

An ever-increasing demand towards sustainable concepts prompts sportswear manufacturers to switch over to eco-friendly, sustainable material procurement, namely recycled polyester, organic cotton, Tencel, hemp, etc. and sustainable practices in sportswear supply chain.

A number of groups such as the Outdoor Industry Association's (AOI) Blue sign, Sustainable Apparel Coalition, guides sportswear manufacturers to practice sustainable principles in their supply chain by the inclusion of regular self-audits and ensuring optimum utilisation of chemicals, water, etc. Accordingly, many sportswear manufacturing units attempt to synchronise style and sustainability. A variety of active wear brands such as Girlfriend Collective, Wolven, Indigo Luna, Stigma, Vyayama, Groceries Apparels, Patagonia, Adidas, Iron Roots, Outdoor Voices and Threads 4 Thought have already adopted sustainable principles and practices in supply chain right from raw material procurement to stitching label, motif attachment and printing on sportswear.

The best example is Girlfriend Collective, an apparel company that produced the first ever black leggings composed of recycled spandex and micro polyester intended for sports freaks.

Patagonia shell jacket is a classic example of sustainable principles adopted in sportswear design and development. The jacket is composed of ECONYL that is 100% recycled nylon.

Wolven, a carbon-neutral brand transforms BPA free bottles to non-toxic fabrics for active wear. Further, the brand offers reusable and biodegradable packaging.

Indigo Luna is another sustainable active wear brand manufacturing yoga wear and swimwear from recycled, organic materials and dyes replacing plastic with biodegradable cassava starch.

Stigma, a sportswear brand produces a range of sportswear assortments from tanks to bras, leggings, joggers and hoodies employing sustainable raw materials such as hemp, recycled plastic bottles and organic cotton in their product mix.

Adidas, a popular sportswear brand is committed to zero waste, and thus works towards reduced water and energy consumption and discontinuing the use of virgin plastic. The company is associated with Parley for the Oceans which aims to preserve water and has come up with 100% recyclable Adidas footwear.

Adidas has been utilising recycled plastic bottles as replacement for virgin polyester. FUTURECRAFT.LOOP, a 100% recyclable shoe will be the latest addition of Adidas to sustainable sportswear segment with an attempt to bring down marine pollution.

Parley, Adidas's partner, collects trash from vicinity of coastal areas, sort and send recovered plastics to Adidas processing plants.

Small plastic flakes are obtained in processing plant by crushing, washing and dehydrating the waste. The flakes so obtained are subjected to heating, drying and cooling and then cut into small resin pellets. The pellets are molten to be converted

Fig. 2 Sustainable virtual sportswear utilising 3D body scanning

into filament and referred to as Ocean Plastic. The upper of Adidas sneakers are constructed using Ocean Plastic.

Patagonia, quite popular for its top-notch quality sportswear, follows triple bottom line catering to profit, people and planet. The brand specialises in sustainable, eco-friendly yoga pants, outdoor jackets, running shorts, etc.

Another breakthrough in sustainable sportswear designing is the inception of convertible, multipurpose ensembles that provide agility to the wearer to embrace different styles with a single ensemble just by addition or removal of certain style elements such as collars, sleeves, hoods, pockets as per the occasion. Convertible sportswear designed from recyclable materials possesses the ability to eliminate waste associated with conventional apparel design and manufacturing process.

Physical prototyping and sampling results in wasteful utilisation of resources with discarded samples ending up as landfills. Accordingly, another trailblazing sustainable approach practised by sportswear brands is the creation of virtual 3D prototypes, thereby eliminating the need for physical sampling (Fig. 2).

5 Conclusion

The sports segment of technical textiles is one of the most promising and innovative avenues that serves as food for thought for researchers, sportswear designers and manufacturers. The inclination of common masses towards fitness and leisure activities prompts them to buy functional yet aesthetic athleisure. The consumers primarily seek performance, health, hygiene, comfort, sustainability and safety aspects in their sports attire. Furthermore, smart features incorporated in sportsperson's clothing can enhance their performance by monitoring their physiological parameters and keep them updated on their workout patterns.

The quest for technology-laced, sensor-integrated smart sportswear is gaining momentum with the advent of technology and smart apps to monitor the wearer's health and well-being. Additionally, sportswear design incorporating sustainable approaches is also garnering the attention of sports enthusiasts and sportswear brands. Consequently, not just sportsperson indulging in performance sports but

tech savvy, fitness freak consumers also prefer a technologically evolved as well as sustainable clothing that can be connected to their smartphone, play music, serve as global positioning systems, keep track on their workout schedule and is eco-friendly too.

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Sustainable Approaches and Sports Apparels

M. Gopalakrishnan, V. Punitha, D. Saravanan, S. Mounika, and C. Mohan Bharathi

Abstract Sports clothing is manufactured in large volumes for a shorter life cycle, leading to a huge waste, when disposed to earth. Synthetic fibres are used in sports apparels for better comfort properties and performances. The latest techniques and manufacturing processes are adopted to produce sustainable sports apparels. Digital concepts have been adopted to minimise material wastes, ensuring reduction in the resource exploitation. In this chapter, along with environmental aspects, social and economic aspects of sustainable development through triple bottom line study, effective material selection with digitalisation in the supply chain, and the influences of slow fashion in the waste reduction are also discussed.

Keywords sustainable manufacturing · Life cycle assessment · Triple bottom line · Digitalisation · Sports fashion

1 Introduction

Sports textiles bring better comfort and functions to clothing of sports persons. Sportswear industries not only include garment production, but also fibres, fabrics production including relevant chemical treatments. Manufacturers are challenged with the need of reducing the consumption of water and energy along with environmental impacts of waste disposal and gas emissions. Sustainable developments can be brought-in manufacturing sections through various approaches from raw materials to manufacturing processes, selection of intermediate supply chain management through digital environments and waste management. Consumers are aware of the

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sustainability and their imprints on environmental concerns, and are ready to spend more to ensure sustainable practices. Increasing concerns among consumers on the planet and environmental health emphasis the industries adopting sustainable manufacturing approaches and many brands of sports apparels create the interests among consumers through appropriate labelling, slogans and stories on the products and goods. However, sustainability practices are not being implemented consistently by the manufacturers due to limitation in infrastructure.

2 Sustainable Manufacturing: Strategy/ Framework Development

Sustainable manufacturing depends on infrastructure, workforce, management practices and technology levels. To implement sustainable strategies in an industry, the supply chain capability needs to be analysed through a framework (Fig. 1) to identify the potentials in terms of three levels, namely (i) capabilities—environmental aspects and standards, (ii) industrial practices and (iii) practical implementation of environment standards in the industry. Environmental aspects and standards deal with energy and water consumption, emission of greenhouse gas, wastewater and solid waste disposals, noise levels and nature of chemicals and usage (Haapala et al., 2013). Levels of environmental aspects and standards and the manufacturing

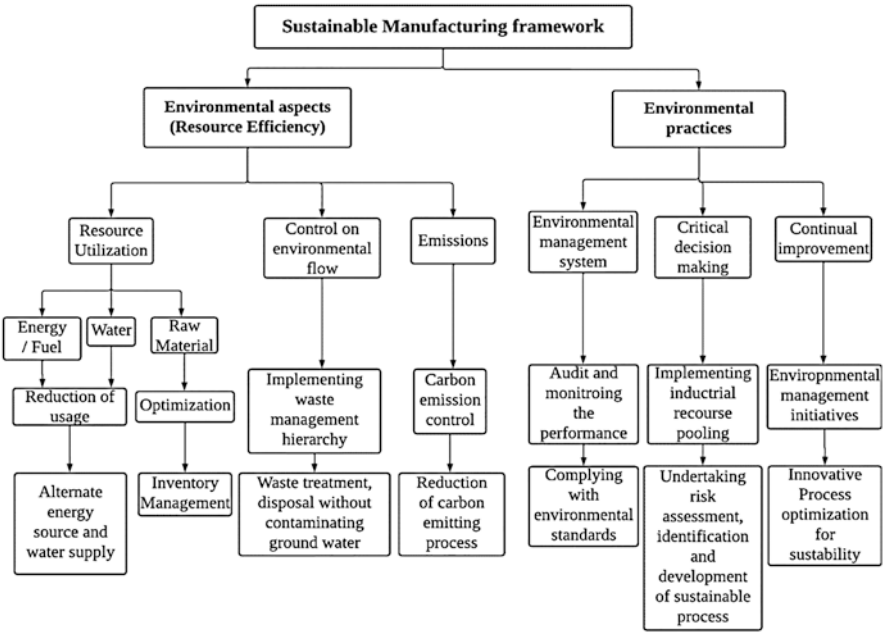

Fig. 1 Sustainable manufacturing framework (Dubey et al., 2015)

Table 1 Steps towards sustainable manufacturing

Area of focus	Expected impact (domain/process)
Resource utilisation and measurement	Energy and water
Hotspot analysis	Emission-intensive processes
Cause analysis	Reasons and resource for emission-intensive performance
Benefit / cost analysis	Social and economic factors to improve sustainable aspects
Targets setting	Selection of internal environmental targets and timelines
Critical decision-making	Establishing a decision-making system for achieving the targets
Auditing and monitoring system	Process to achieve environmentally sustainable process and verify performance with standards

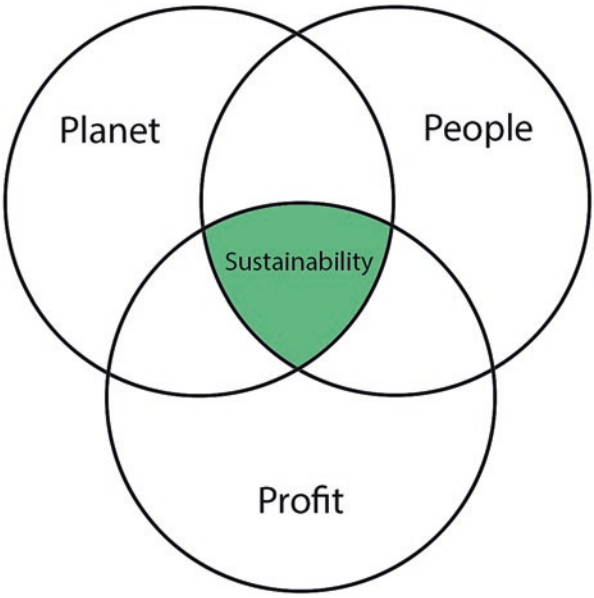

Fig. 2 Triple Bottomline Principle – a schematic representation (Abraham, 2006)

practices motivates the management to initiate sustainable approaches in the manufacturing processes. Achieving the consciousness in following practices lead to the beginning of sustainable manufacturing process (Table 1).

Hotspot and cause analysis involves certain questionnaire practice that includes (i) WHICH—identify emission-intensive processes, (ii) WHY—identify causes of the with reasons, (iii) WHAT—identify benefits and costs for environment concerned, alternates or modifications in the process, (iv) HOW—compare alternates, process modifications and selecting suitable options (Dubey et al., 2015).

Sustainable development can be achieved by imposing strategies for sustainable framework in entire sequence with social, economic and environmental dimensions (Fig. 2) – *Triple Bottomline*. But there are always conflicts among these dimensions

and to be compromised when single dimension attains the higher focus, e.g. generating revenue to the industry (profit) (Jensen, 2010).

3 Sustainability Assessment for Enterprises

Sustainability assessment is often considered as an extension of general environmental assessment techniques like EIA (environmental impact assessment) or SEA (strategic environment assessment) or SIA (social impact assessment) (Pope et al., 2004). Assessment of sustainability competency involves collecting reliable evidences using assessment tools on sustainable competencies and it starts with two key questions (i) what to assess (knowledge, skills, attitude) and (ii) how to assess (strategy for assessment and interpretation and tools) (Remington-Doucette et al., 2013).

Approaches followed in the sustainability assessment are classified into (a) indicator / index-oriented approach, (b) product related approach and (c) integrated assessments or (a) monetary, (b) biophysical and (c) indicator-oriented approaches. It is often recommended to have a comprehensive and holistic assessment that may require participation from different domains / disciplines and stakeholders with system approach (Abraham, 2006).

4 Eco-Design

The concept of eco-design covers the *design for sustainability*, *design for environment* and *designs for recycling,* individually to influence the consumers in fashion industry. Eco-design lays emphasis on environmental aspects and plays a significant impact on the entire sustainable supply chain starting from material selection, designing, manufacturing process, and distribution systems (Köhler, 2013). Many fashion brands show interests in the elements of eco-designs for sports apparels with increasing awareness. Recycled, organic and traceable (in their lifecycle) materials are used in the eco-designs for environmental sustainability. The focus of eco-design is not only following aesthetic demands and trends to sustain in the market, but on eliminating harmful processes, resources and methods for sustainable practice. New product design, improvement in existing design and alternate materials for the design are key decision categories for the eco-design process (Pashkevych et al., 2020).

Manufacturers follow cradle to cradle model, applied in the eco-design process where they are encouraged to work with designers for sustainable fashion at every stage of sample production to final product, along the supply chain members especially at fabric selection. Eco-design further classified into functional and aesthetic, based on consumer lifestyle. Both aesthetic and functional performance of

sportswear have greater impacts on the decisions in manufacturing process and supply chain in terms of sustainable measures (van der Velden et al., 2015; Cicconi, 2020).

5 Eco-Labels

Eco-labels are defined as the labels containing details of the raw materials used to create the product along with certification logos and slogans received for the product by following sustainable measures. Information available on eco-label guides the consumers on the care system of the product that helps in extending the lifespan of the products. Eco-label includes slogan or statement of stories telling the consumer about their sustainable inspirations on sustainability and how the products are occupying the stores with great concern on triple bottom line theory (Nimon & Beghin, 1999; Žurga & Forte Tavčer, 2014; Vadicherla & Saravanan, 2015; Dreyer et al., 2016).

6 Life Cycle Assessment and Sustainability Certification

Life cycle assessment is one of the major parts in sustainable approach in textile manufacturing. Where the emissions and carbon footprint can be evaluated and the outcomes will be useful to the designers and manufacturers to select appropriate sustainable materials in manufacturing. In eco-design, supply chain members consider the stages that a product undergoes during its life span. Stages of a textile product, post-retail include (i) frequency of washing and (ii) laundering conditions, while the life span of a textile sports clothing depends on (i) durability (wear and tear), (ii) aesthetic (boredom), (iii) garment fit (poor fit), (iv) cost of the product and (v) possibility of repair and recycle. To increase the life span, designers concentrate on functional quality with longevity in aesthetic and fashion trend supported by colour and style (Roy Choudhury, 2014; Muthu, 2015).

7 Sustainable Standards and Certifications

Although there is no compliance-driven mandate to get certification for sustainability, it helps in creating awareness among consumers and encourages the industry in terms of flexibility, and maintaining habitual buying among the consumers (Muthu, 2015; Warasthe et al., 2020). Certifications standards are categorised based on supply chain in which the industry practises the sustainability: (a) sustainable fibres (recycled, organic, and bio based) – Table 2; (b) environmental certifications – Table 3 (chemicals and reagents for cultivation and processing); and (c) complete business model (holistic certifications) – Table 4.

Table 2 Sustainable fibre standards (Senthil Kumar & Suganya, 2017)

Certification	Impact/outcomes
Oeko Tex	Arsenic, lead, phthalates, formaldehyde, pesticides are tested for certification and also the pH level that is acceptable for human skin. Testing products against 350 toxic chemicals present in the product from yarn to the end products
Organic Content Standard – OCS	Material contents and amounts in the final product that are organically grown are tracked and verified
Global Organic Textile Standard	Organic textiles contain minimum of 95% of organically grown fibres (with 5% synthetic fibres) and minimum 70% of fibres from organic agriculture (min. 10% of synthetic fibres and in case of footwear or sportswear min. 25%)
Regenerative Organic Certified	Has three levels gold, silver and bronze and focused on soil health and land management, welfare of the animal and fairness of the farmer and worker
OE 100	Organic Exchange OE-100 is provided to the products which are made with 100% organic fibres
USDA Organic	Requires production of agriculture products through USDA approved method; requires at least 95% of certified organic content or 70% certified organic content for certification 'made with' organic
Global Recycle Standard – GRS	Recycled materials present in the end products is tracked and verified
Woolmark	Woolmark licensing guarantees the fibre content and quality of the wool to consumer and supply chain, products with logo are made with 100% pure new wool

Table 3 Environmental certifications (Muthu et al., 2008; Lo et al., 2012)

Certification	Impact/outcomes
Better Cotton Initiative – BCI	Promotes better standard in cotton cultivation by multi-stakeholder governance group that impacts on environment and improves economic development
B-corp	Provided for the social and environmental performance of the company
Blue Sign	Standards for environmental safety and health. Chemicals are given three categories blue (safe to use), grey (special handling required), black (forbidden). Has five principles such as resource productivity, consumer safety, water emission, air emission and occupational health and safety
Cradle to Cradle – C2C	Based on global standards for safe, circular and responsibly made products—on five categories, material health, product circularity, water & soil protection, clean air & climate protection and social fairness. Five levels of certification of products such as basic, bronze, silver, gold and platinum
Ecocert	Certified in trade and environmental management system. The label 'Natural and Organic Cosmetics' has minimum 95% of formula with plant-based ingredients and minimum 10% of ingredients weight come from organic farming

Table 4 Business certifications (Lo et al., 2012)

Certification	Impact/Outcomes
B – Lab	Helps to translate the sustainable development goals into business processes
Fair Trade International	Multistakeholder group based on product oriented aimed to improve the life of workers and farmers through trade
NSF International	Product testing, inspection and certification
Solidaridad	Aims the development of socially responsible, environment friendly and profitable supply chain
Sustainable Apparel Coalition	Leading alliance for sustainable production to reduce the environmental and social impact on apparels, textile and footwear products.
Ethical Trading Initiative	Works to improve working status of the people who produce raw materials or consumer goods producer

8 Digitalisation

In sports apparel manufacturing and trading, digital methods increase the profit besides contributing sustainability through different ways. Digital scanning by RFID helps in tracking the supply chain and details of footprints and maintains transparency along the supply chain. The technology reaching metaverse world, fashion designing is possible in the digitalised world helping to reduce the resource utilisation for design creation and sample production specifically. Digital design reduces both utilisation of materials and engagement duration of skilled persons. Digitalisation in textile and fashion supply chain offers the following key advantages towards sustainability (Table 5) (Bertola & Teunissen, 2018; Martinez, 2019).

9 Sustainability in Material Selection for Sportswear

In textile and fashion, material selection plays major role as different fibre materials consume different levels of energy and water at different stages of processing.

As a part of sustainable practices, efforts are made to produce garments that are recyclable, reusable or biodegradable to reduce wastes. Recycled polyester (rPET). Polyester fibres are one of the preferred raw materials for active wear. Main advantages of using rPET in sportswear includes affordability, durability and more functional than many natural fibres. The polyester fibres can be produced three times finer than silk fibres and is blended with spandex or elastane to enhance the stretchability. Recycled polyester fibres are commercially made from industrial wastes, pre-used polyester garments and PET bottles. Recycling reduces landfills, energy consumption as well as the carbon emissions and saves products quality without negative impacts (Guppyfriend, 2022).

Recycled nylon is another commonly used in sportswear fibre, especially in swimwear. Similar to rPET, recycled nylon is blended with spandex or elastane for

Table 5 Digitalisation and advantages

Business process	Impact of digitalisation
Scalability	Digitalisation helps in reduction of manpower assigned
Transparency	Digitalised process information are fair statistics, connects all stakeholders
Customer satisfaction	Digitalisation aids communication from the business to the customers and supports healthier customer relationships
Virtual sample development	Helps fabric fitting in virtual reality that reduces physical sampling and carbon footprint. Manufacturing is carried out by digital machines for less error and identical quality
Sourcing / procurement	Reduces inventories and document storage
Circular logistics	Tracing and tracking
IoT smart wardrobe	Saves the time in arranging, using and blueprinting the wardrobe
Fast Fashion	Accurately tracking the stocks through the supply chain allowing the small shops to make reasonable market decisions

elasticity. Nylon fibres are recycled from the post-consumer and post-industrial wastes such as carpets, fishing nets, scraps from fabrics, etc. Properties of recycled nylon fibres find applications in sportswear that are durable, strong, soft, flexible and recyclable (Alex Assoune, 2022).

Bamboo is a substitute for cotton fibres. Naturally, bamboo fibre has wicking tendency with softness, and suitable for garments, yoga wear, after workout garments, trekking clothing (Imadi et al., 2014).

Cotton is the oldest and renewable natural fibre. It is soft and gives a pleasant feel to the skin, suitable to only limited extent as it dries poorly. This sustainable organic cotton uses less amounts of water than conventional one due to the use of sustainable chemicals and dyes during processing. For an excellent sustainable sportswear, the organic cotton is blended with spandex and such garments possess lightweight, durable, comfortable, moisture-wicking, fast drying and biodegradability (Chouinard & Brown, 1997; Sung & Lee, 2011; Coppedè et al., 2014).

Merino wool naturally keeps the wearer warm in the cold and, cool in the heat due to its moisture-wicking properties. Merino wool is resistant to odors and static charges and easily washable. Merino wool finds applications in trekking clothes, winter sports garments, after workout outfits, yoga wear, running clothes and clothing for gym workout (Wang et al., 2014; Alderson, 2015; Chaudhari et al., 2004).

Hemp fibre is the most sustainable and a substitute for cotton fibres. Hemp is strong, naturally UV and microbial resistant fibre, moves easily with the human body, breathable and exhibit thermo—regulating properties. Additionally, hemp compared with linen fibre wrinkles less and required occasional or low temperature ironing (during the use). However, its less stretchability limits the applications as sportswear, which necessitates blending with spandex fibres (Wambua et al., 2003; Wood et al., 2011; Begum et al., 2020).

Linen is a natural sustainable fibre used in activewears. Linen fabrics are mostly preferred in hot and humid condition as it releases moisture in air. As a sustainable

fibre, it is used in sportswear due to the certain inherent properties that include durable, absorbent, strong, quick drying, wicking, lightweight, antimicrobial and biodegradable (Buckley, 2005).

Fibres with diameter less than a denier, categorised as microfibres, possess valuable properties such as softness, durable and high absorbency required for a sportswear. Ultrafine fibres are found to have fibre diameter less than 0.3 denier and commonly produced by the process of bi-component fibres (Stegmaier et al., 2005).

A fibre with two polymers chemically or physically different are termed as bi-component fibres and used in sportswear such as t-shirts, shorts and sweatshirts. Bi-component fibres are produced as concentric sheath and core—sheath made of polymers having low melting point and core with polymers having high melting point, eccentric sheath and core— core is found to be out of centre, side-by-side—two polymers with equal share, pie wedges— hole is provided at the centre of the pie wedge to split the filaments and islands/sea—one type of polymer is dispersed (island) in another polymer (sea).

10 Fabric Selection for Sportswear: Sustainable Approach

Sportswear are designed to provide ease of movement along with the human body. An activewear gives protection from external elements and balance the heat produced by the wearer. When excess heat is produced due to high metabolic rate, the fabrics should have the capability of dissipating the heat and cause perspiration. Fabrics made of woven and knitted possess the desired characteristics such as tactile properties, liquid absorption, thermal insulation and evaporating water to stay dry. Coated and laminated fabrics are commercially used in sportswear for their breathable and barrier characteristics against external factors, when fabrics are manufactured using microporous, hydrophilic membranes, water vapour transmission membranes, etc. Phase change materials provide thermally adaptive technology in sportswear and activewear and finishing with such substances help in interacting with microclimate and responding to the fluctuations in temperature caused by the levels of activities. Table 6 lists some of the characteristics of sportswear required for various activities (McCann, 2015, 2016; Shishoo, 2015; Wang & Shen, 2017).

Table 6 Fabric characteristics required for sportswear

Type of sports	Fabric requirement
Aerobic/ gym wear	Stretch, opacity
Ball sports	Sweat absorption, breathability, quick drying, cooling
Athletics	Sweat absorption, breathability, quick drying, cooling, stretch
Water sports	Water and air resistance, stretch, opacity
Snow sports	Water proof, water vapour permeability, fast drying and temperature balance
Motor sports	Good tenacity, thermal retention, low air resistance
Contact sports	Lightweight, flexible, shock absorption and protection

Waterproof breathable fabrics are designed to give protection from environmental factors such as wind and rain, and heat loss from the body. Breathability is an essential characteristic expected in the case of fabrics finished with high waterproofness and breathable waterproof fabrics including closely woven fabrics, hydrophilic membranes and coatings, microporous membranes and coatings, combination of microporous and hydrophilic membranes. Closely woven fabric is made up of long staple cotton fibres. When such fabric becomes wet, the cotton fibres swell up and reduce the pore size in the fabric between the yarns. The characteristics of waterproof fabrics include air permeability and breathability are found to be improved. Another possible way of producing closely woven fabric is by using microfilament synthetic yarns.

Swimwear is clothing that is used for swimming designed for all categories of men, women and children and it combines swimsuit, cap and eyewear into a single piece of outfit. A swimwear is designed considering the basic requirements including biomechanics of swimming, measurement of drag force, physiological and biomechanical responses during swimming; such designs allow swimmers to move comfortably with increased hydrodynamic efficiency. Initially, swimsuits were made up of silk fabrics for properties such as lightness, strength, elasticity and feel. Fibres that are commonly used in swimwear include nylon, polyester and elastane for stretch and resilience. Texturised filaments with modified stretch yarn (false twist) is commercially used in swimwear compared with spun yarn. Tricot produces adequate two-way stretch and in jersey fabric elastomeric material is used for stretching and body fitting. Rib structure is also found to be more elastic than single jersey. So the commonly used rib structure for swimwear is interlock and Swiss pique using stretch nylon and stretch polyester (Moran, 2014; Bloodhart & Swim, 2020; Chau, n.d.).

Skiers and snowboarders require a sound protective gear to prevent physical damages, fitted with airbags to prevent injuries (Parkkari et al., 2001). Apparels with sensors are used to secure areas prone to abrasions to avoid inquires, while jackets equipped with sensors spontaneously adjust temperatures based on weather conditions. The water resistant and moisture-permeable materials are further categorised into (i) densely woven waterproof breathable fabrics, (ii) laminated waterproof breathable fabrics, (iii) coated waterproof breathable fabrics. Moisture vapour transmission in activewear deals with temperature and pressure gradient that exist between inner and outer faces of a garment. Moisture transmission takes place through absorption, wicking and evaporation. Sweat generation would be very during high sporting activities and hence instant wicking and evaporation is required to ensure the comfort levels of the players. Wigwam socks are made up of merino wool combined with hydrophilic and hydrophobic fibres that regulates body temperature. When the atmosphere outside is cold, the natural blends present in the fibre traps the warm air and when outside environment is found to be warm, merino wool quickly traps the sweat from skin to keep cool and dry. Moisture is wicked by the socks and

released through the air mesh linings of the boot. By pairing right choice of socks and boots, an environment of cold and clammy feet can be created where moisture and heat can escape (Laskowski, 1999).

Densely woven waterproof breathable fabrics are constructed using cotton or synthetic microfilament yarns with tight fabric structure, e.g. *Ventile*. Long staple fibre-combed-yarns are used with Oxford weave for minimum porous structure, which, when swells transversely reduces the pores further there by necessitating more pressure for penetration.

In the laminated materials, thin membranes produced by polymeric materials of 10 microns thickness allows the water vapour to pass through but prevents water-drop penetration. Further, the membranes can be of two types, namely (i) microporous membranes, having pore size smaller than rain drops but larger than water vapour molecule, produced using Poly(tetra fluoro ethylene) and Poly(vinylidene difluoride), (ii) hydrophilic membranes—made up of chemically modified polyester or polyurethane that forms amorphous regions in the main polymer units, which functions as intermolecular pores to allow passage of water vapour molecules and resist liquid penetration. In the case of coated fabrics, polymers such as polyurethane is applied as a coating on the surface of the fabric as either microporous (fine interconnected channels) coat or hydrophilic coat (breathability through by adsorption—diffusion and desorption mechanism). Polyester fabric with hydrophobic inner side and hydrophilic outer side is the commercially used fabric for high active sportswear for superior moisture management along the fabric thickness.

GoreTex is a two-layered membrane made up of stretched polytetrafluoroethylene (PTFE). This membrane contains micropores whose pore size is larger than water vapour and smaller than water droplet, suitable for golfing, cycling, skiing, running, etc. *Pro* is a three-layered membrane with membrane sandwiched between outer and inner lining that ensures durability and suitable for winter climbing, sailing and snowboarding (Virk & Kocher, 2011; Slack, 2014).

Phase change materials (PCMs) provide a sustainable approach to sports textiles by reducing the need for constant washing and drying, thus conserving water and energy. PCM can absorb, store and release energy (heat) for moisture and temperature management thereby providing comfortable microclimate. High levels of sporting activities result in dissipation of heat energy from overheated skin, where heat is absorbed by phase change materials and making the skin cool down, and dries the sweat of skin while stored heat is returned. This technology proactively stops the body from sweating by regulating the skin temperature. By regulating the microclimate and absorbing and storing heat energy, PCMs prevent overheating and excessive sweating, keeping the skin cool and dry. This reduces the need for frequent changes of clothing and washing, reducing the environmental impact of textile production and usage. Additionally, PCMs can be incorporated into sports textiles using eco-friendly materials, further promoting sustainability in the sports industry (Mondal, 2008; Ye, 2014; Kwiecien et al., 2020).

11 Conclusion

Developments in the science and technology has led to additional competitive elements in all the sports and games in terms of comfort levels with which a player is performing and the efforts made by the manufacturers and endorsed by the players in promoting sustainable features associated with their actions and intents. There many ways available in promoting sustainability during manufacturing—in terms of fibres, processes and supply chain nature while thrid-party agencies try to suggest parameters, metrics and targets for sustainability labelling. Volunteering of manufacturers and the players in adopting conscious measures to promote the sustainable practices further.

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Fluctuating Attitudes of Target Consumers for Sustainable Fashion Markets Across India

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Abstract Customers in India are getting more concerned with the concept of sustainability, especially millennials who have been identified as the most active, informed, and sensitive generation in terms of purchasing behaviour and consumer decisions. The reality is that India has the world's largest millennial population which provides the basis for this chapter's focus. The study explores the motivations behind millennials' interest in sustainable items. It is believed that these millennials have enormous spending power; they have a great desire for working in environmentally pleasant workplaces and have a significant inclination to purchase eco-friendly items. But the reasons why millennials buy sustainable products have not been thoroughly studied. Many countries, including India, face difficulties in shifting consumer behaviour towards more ecologically responsible purchase. Nowadays, consumers have gotten more knowledgeable about the items they buy and how they are created. The purpose of this chapter is to learn how Indian patrons feel about sustainable fashion, their attitudes, motivations and behaviour towards sustainable fashion. Furthermore, a comprehensive framework for understanding and promoting long-term shifts in consumer behaviour is developed. Since providing a guideline for moral consumption and manufacturing is critical, the fundamental aim of this research is to acquire a thorough knowledge of the modifications that sustainable fashion suggests. This has been achieved by considering two case studies, examining the sustainable strategies and behaviour of H&M, a Swedish multinational

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fashion house, and of Stella McCartney, a Milan-based luxury designer, focussing on publicly accessible data. Both case studies discuss the sustainable initiatives and measures that urge client purchasing attitudes to modify their purchasing decisions in favour of the expansion of sustainable fashion.

Keywords H&M · Indian millennials · Purchasing attitude · Stella McCartney · Sustainable fashion · Sustainable measures

1 Background

Climate change has emerged as one of the most significant issues confronting humanity in recent times, mainly in the twenty-first century (Pereira, 2015). Rapid population growth has resulted in higher demands placed on available resources and contributed to an increase in the number of emissions of greenhouse gases. In addition, an alarmingly fast pace of depletion of natural resources has occurred as a direct result of the dramatic increase in demand (Khurana & Ricchetti, 2016). As a direct consequence of this, the idea of sustainable development has emerged as one of the most compelling issues to be discussed in the academic, business, and consumer sectors in the twenty-first century. The 'Brundtland Report of 1987', which is a manuscript that analyses human desires for a more satisfying life and the constraints imposed by the natural world, is the source from which the notion of sustainability was formed. The International Union for the Conservation of Nature (IUCN) provides the following definition of sustainability: 'the capability to raise the quality of human life while living within the capacity of Planet Earth's helping eco-systems' (IUCN, 2018). As a result, the three primary components of sustainable development, which are the generation of wealth, the advancement of social conditions, and the safeguarding of the natural environment, all work collaboratively toward a common objective.

Fashions that are environmentally friendly, ethical, green, and slow fashion are all examples of alternative terms for sustainable fashion. Many of the world's largest fashion firms are rethinking their manufacturing processes in an effort to become more environmentally conscious in response to the rise in popularity of the phrase 'sustainable fashion'. Increasingly, conscientious consumers are making purchases from companies that are concerned about the wellbeing of their employees and the natural environment. The percentage of individuals who go out of their way to find sustainable brands that are conscious of their impact on the world around them and make an effort to incorporate environmentally responsible practices into their operations, is rising. There has been a radical shift in the fashion industry's commitment to sustainable practices in recent years. Customers are increasingly demanding sustainable apparel as they learn about the environmental devastation caused by fast fashion.

In addition, the fashion business has been one of the industries that causes the most damage to the environment throughout the world for several decades

(Henninger, 2015; Vlachos & Malindretos, 2015). In the fashion market, the practice of rapidly introducing new products at low costs in response to changeable customer requirements is referred to as 'fast fashion'. One of the key reasons why the industry is so risky is because of the way that it is made and consumed today. Demand from customers in western markets has increased at a phenomenal rate during the past two decades (Khurana & Ricchetti, 2016). In today's modern age, customers hardly seldom purchase something brand new unless it is broken or they have an exceptional requirement for it (Pal, 2016). Instead, consumers are constantly encouraged to purchase new products through various means, such as constant updates on social media (Pal, 2016). The fashion business is responsible for having a negative impact on the world because it is responsible for spotting trends, as well as crafting, making, and delivering garments around the world in a matter of weeks (Park & Kim, 2016). Nevertheless, the carelessness and hunger for higher profits that characterise the fashion business are a contributing factor in the deterioration of the environment; despite this, the fashion industry has emerged as a pioneering adoptive parent in the field of sustainability (Henninger, 2015). The fashion industry has shown a remarkable dedication to environmental protection over the past few years; this cycle continues, with an increasing number of firms taking matters into their own hands by making either incremental or radical shifts in their manufacturing processes to ensure that their apparel is produced in a more environmentally friendly manner. This cycle will continue as long as the fashion industry continues to demonstrate remarkable dedication to environmental protection (Henninger, 2015).

However, there are a vast number of areas of sustainable fashion that provide substantial challenges for firms. The fashion business is plagued by a significant problem known as overproduction, which can be attributed to a variety of things, such as sudden fluctuations in consumer demand and impulsive purchases. Not only is there an excessive amount of clothing being produced, but also approximately 30% of all garments wind up in landfills after they have been 'consumed'. It has not been determined whether the items are recycled once they have been used (Ekström et al., 2015). It is also unknown whether they are thrown away.

Millennials are more socially and environmentally conscious than previous generations, despite being a generation that is focused on consumption, as noted by Ekström et al. (2015). The youth of today have been educated about the topic of environmental sustainability from a young age, in contrast to the youth of past generations, who had to wait until they were much older to learn about it. There may be generations who are more concerned of the environment than others, yet even such generations are nevertheless guilty of overconsumption and waste. According to studies that were carried out by third-party organisations, millennials (people who are between the ages of 20 and 30) are more likely to spend more money on sustainable brands, nearly 50% of consumers will intentionally buy from vendors owing to their commitment to a cleaner planet, and more than a significant proportion of consumers would start boycotting garments from companies if they started learning that the organisations were not dedicated to the goal. This is a brilliant example of

how young people's shopping habits have become less rigid and more open to change in recent years.

As contemporary fashion consumption patterns have negative repercussions for the environment, there is an increasing level of concern over environmental issues within the apparel business (Choi & Cheng, 2015). Because of this, organisations and corporations from all around the world are coordinating their efforts to lower these figures (SAC, 2017). According to Gill et al. (Gill et al., 2016), two of the ways that these figures might be lowered are by increasing product durability and developing items that can be recycled. Companies are meeting the growing demand for environmentally friendly goods by releasing 'conscious collections', marketing environmentally friendly cotton goods, and publishing care guides (Henninger, 2015). The fact that 'sustainable' labels are appearing on an increasing number of products is an evidence that more and more businesses are striving to help improve the state of the world.

In the fashion industry, retailers operate as intermediaries between consumers and the many brands that provide their desired goods. If the corporation engages in any kind of inappropriate behaviour along the supply chain, the organisation's reputation will be damaged. Because of this, large retailers are advocating for changes in production processes and customer behaviours that will assist in mitigating the adverse consequences on society and the environment. Retailers have a tremendous amount of sway over how changes in production processes and consumer shopping habits are implemented. They are strongly encouraged to impose sanctions on production companies to promote consumption patterns that are more self-sustaining. In response to challenges on a global scale and shifts in societal norms, the fashion industry has started to consider expanding its focus beyond its usual confines. The garment business as a whole has become more environmentally, morally, and socially progressive as a direct result of the growing awareness among consumers on the social ramifications of the industry. In today's business world, consumers exert pressure on companies through their goals as investors, their commitments as customers, and their expectations on ethical behaviour. All the way from raw material collection to final product disposal, the ecological effect of the fashion market can be lessened.

Among consumers in today's society, there is a growing worry about pollution, rising water levels, non-biodegradable effluents, and the degradation of finite natural resources, all of which have led to an increase in the demand for ecological and certified organic textiles. As the manufacturing industry undergoes a dramatic transformation as a result of the efforts of both garments manufacturers and customers, it has appeared that self-sustaining, long-lasting strands and fibres will be the future of textiles. This is due to the fact that self-sustaining, long-lasting strands and fibres are the future of the industry. Sustainable clothing has the potential to become more than just a passing trend; it has the capacity to affect the future of fashion and the way we live.

Because textiles are put to use in such a wide variety of applications, the textile industry is responsible for a wide range of environmental impacts. The modern consumer is expected to have a concern for the environment and a commitment to

working toward a more desirable future. As a consequence of this strategy, there is a great deal more pressure placed on the textile industry to innovate in the direction of environmentally friendly clothing and textiles. If an item of clothing is better for the skin, the environment, or other social concerns, the modern consumer is more likely to spend more money on that item even if there are less of them.

Customers are the focus of many movements within the fashion business, such as #WhoMadeMyClothes, which have the goal of educating consumers about the entire production process. Customers today are concerned not only with how a product makes them look and feel, but also with the health and happiness of the person who created it (Grazia, 2018). Because of the increasing environmental consciousness of consumers, the fashion industry has no choice but to shift its focus to more environmentally friendly practices. The growing awareness among the general public of the depletion of natural resources as a direct result of human activity has led to the emergence of the discussion surrounding ecological management and environmental consciousness in patterns of consumption. As a result of this, there is an increased demand for products that are favourable to the environment. Because it is critical to have an understanding of both the consumer base and the factors that influence purchasing patterns, researchers have been putting a lot of effort into trying to comprehend the features of customers who are environmentally conscious in various marketplaces. Because it is difficult to strike a balance between a company's socioeconomic and environmental needs, both academics and practitioners have increased their focus on sustainability as an essential managerial issue. This is a trend that can be attributed to the rise of the green economy.

1.1 Overview

Sustainability has become a new trend nowadays, especially after COVID-19. Clothing manufacturers, designers around the world and numerous fashion brands such as Patagonia, Levi's, Everlane, H&M are all inclined towards sustainability. They are moving away from the use of materials that are harmful for the environment and have started using vegan sources. All of these are aiming to use only sustainable sourced materials in the coming time. This way the brands are working on to enhance their reputation in the minds of the customers, thereby increasing the sales and boosting their income. Previous studies show that majority of the millennials are eco-conscious due to which they are ready to shift their buying preferences and favour the eco-friendly environment. Not only they are environment conscious but also, they have high purchasing power. They are the ones who are working for social cause. Further, to have a better understanding, the chapter studies the sustainable initiatives and behaviour of H&M, a Swedish multinational fashion house, and of Stella McCartney, a Milan-based luxury designer.

2 Ethical Consumer Buying Behaviour

'Ethical purchasing behaviour' refers to the act of buying products that provide less of a risk to the health and safety of humans, animals, and the planet. Items that are not harmful to the environment include things such as eco-friendly tote bags, recycled papers, compact fluorescent lamps (CFLs), light-emitting diodes (LEDs), high-efficiency appliances, green cleaning supplies, and many more. These products are considered to be environmentally friendly due to the fact that they are made from recyclable and non-toxic materials and come in little amounts of packaging. Studies conducted in the subject of green consumer psychology have revealed that consumers' intentions significantly impact the products and services they end up purchasing (Wei et al., 2017). Consumers often give serious consideration to how the global community will react to the environmentally responsible products they buy.

Examining a consumer's level of readiness or interest in making purchases that are good for the environment is one method to determine whether they have environmentally responsible shopping habits. Such products are made in a method that reduces the amount of damage they cause to the environment during production; as a result, they are recyclable and generate very little trash. The practice of buying things that are beneficial for the environment is sometimes referred to as 'green purchasing'. The term 'green consumerism' refers to a shopping strategy that helps mitigate the influence of the manufacturing process on the atmosphere. The consumption of products that have a high environmental impact, such as automobiles and home appliances, can have a more significant effect on the natural world than the manufacturing procedure itself. The second kind of purchase that is more conscious of its influence on the environment is the one that stands out the most.

According to a vast body of research, customers that care about the environment are much more inclined to make a purchase than their less concerned counterparts. The average Indian customer has the least amount of expertise when it comes to selecting ecologically friendly items. According to the findings of a study that was carried out by the Green Purchasing Network of India (Green Purchasing Network of India, 2014), the lack of environmental consciousness that is prevalent among Indian consumers may be discouraging businesses from developing environmentally friendly products to sell in India. Businesses have the potential to improve their products and services by educating Indian customers about the advantages of purchasing environmentally friendly goods. Therefore, if we want to change people's minds about buying environmentally friendly goods, it is necessary to raise consumers' levels of knowledge and awareness of the items in question.

3 Consumer Behaviour in the Fashion Market

Different industries see different consumer actions and behaviours, and the fashion industry is no exception (Strähle, 2017). Many designers in the past have tried to decide what people should like and dislike in terms of fashion, but in the twenty-first

century, fashion houses and retail chains are more concerned with satisfying customers' desires and needs. As mentioned, understanding the consumers' motivations is crucial for satisfying their needs. Retailers and manufacturers in the fashion industry need to be ready for the challenges they will face by keeping an eye on consumer preferences and needs. While the topic of motivation is heavily explored in the study of consumer behaviour, it is important to note that the factors driving behaviour in various sectors vary considerably. Buying clothing satisfies an 'emotional need', as stated by Strähle (2017). Many historically fashionable people have made highly sentimental purchases based solely on the designer's name. For instance, before Calvin Klein, jeans were a functional garment worn by workers and purchased based on consumers' rational needs and wants; his influence sparked the creation of the designer jeans industry.

Nowadays, people use their clothing choices to make a statement about who they are. Clearly, a person's sense of self plays a significant role in their consumption of clothing. People of many different cultural backgrounds share a strong desire and need to feel part of a community. Most shoppers go into the fashion industry looking to make a statement about who they are and what they stand for (McNeill & Moore, 2015). Consumers' desire to express who they are often takes precedence over more practical, ethical, or even sentimental considerations when shopping for clothing. But this depends on people being unaware of the harm that the fashion market causes to the planet. McNeill and Moore (2015) focussed that factor such as price, value, market dynamics, and brand image are more crucial in determining consumer behaviour when it comes to the fashion industry.

As mentioned, the type of purchase decision a consumer makes varies widely. For consumers who fall into the limited decision-making category, making a purchase is a matter of narrowing their options to a select few viable options and ultimately settling on a single brand. This is typical of fashion consumer behaviour, as the acquisition of an article of clothing serves as an excellent illustration of the process. Overconsumption can occur when the decision-making process is dominated by social considerations and the need to appear relevant to others, as is the case in the fast fashion industry (Strähle, 2017).

4 Sustainability in the Fashion Industry

Even if sustainability is now an important part of the decision-making process or is rapidly becoming one, the vast majority of individuals still do not take it into consideration. On the other hand, it is turning into a more essential factor for purchasers (Strähle, 2017). It is a challenging issue to define what 'sustainable fashion' even implies because the fashion industry does not have a uniform definition for the word 'sustainable fashion' (Lundblad & Davies, 2016). It is possible that one could be led to assume that the two ideas are irreconcilable due to the quick rate of change and the relatively short lifecycles that exist in the fashion industry (Lundblad & Davies, 2016). Natural, slow fashion, eco fashion, reasonable trade fashion, and so on are all

examples of sustainable fashion; each of these fashion movements aims to embrace a different political concern, ranging from worker's rights and animal rights to environmental protection and fair trade (Lundblad & Davies, 2016). In response to the increased interest shown by customers, a number of businesses in the retail and brand industries have taken a stand on the topic of sustainability (Lundblad & Davies, 2016).

Furthermore, as Lundblad and Davies (2016) point out, self-sufficient customers are confronted with a wide variety of decision-making drivers. Possible motivational causes include the need to express oneself, the want to be accepted by others, the pursuit of aesthetic gratification, the desire to behave in an ethical manner, and the wish to avoid uncomfortable feelings. Additionally, consumers who shop for sustainable fashion do not place the same importance on low prices; rather, they see higher prices as a necessary trade-off for the use of sustainable materials, the scarcity of those materials, and the time spent researching environmental or social issues. This is because consumers who shop for sustainable fashion believe that higher prices are a necessary trade-off for the use of sustainable materials. Users gain the benefits of long-lasting, one-of-a-kind designs; considerably better textiles; and emotional benefits such as a sense of achievement, uniqueness, and self-esteem as a result of this. Consumers who are committed to social responsibility are motivated to make purchases because they know they will improve both themselves and the world around them by giving their money to companies that ensure a safe and healthy working environment for their employees and engage in practices consistent with fair trade. The desire to exhibit one's individuality while simultaneously seeming their best, feeling their most comfortable, and possessing products that are thoughtfully created is something that unites all customers of fashion.

It is important to note that more research is required in the apparel sector than in any other industry to properly understand how customer behaviour relates to the buying of environmentally friendly products. This is because the fashion business is the one that not only endures the highest rate of change overall but also generates things with the highest rate of change.

5 Eco-friendly Fashion and the Indian Economy

The Indian market accounts for a sizeable portion of the overall sales of textiles produced in worldwide factories. The apparel and textile sectors in the United States contributed close to $100 billion to the country's economy in 2019. Because more people in India are becoming environmentally concerned, there is a significant demand in the country for apparel that is made from sustainable materials. In terms of environmental consciousness and lessening their impact on the surrounding ecosystem, fast-growing cities such as Mumbai are working hard to close the gap with environmentally conscientious metropolitan areas such as Delhi, Kolkata, and Bengaluru. As a result of the increased demand for organic and natural clothing, a number of well-known brands have introduced their very own interpretations of

these types of garments. Each and every one of these companies is very ecstatic about the great replies from clients that they have received. A rising number of well-established brands are adopting this strategy to compete with the expanding number of start-up companies that are focused on producing eco-friendly clothes.

6 Ethical and Sustainable Consumption: Intention vs. Behaviour

If sustainable consumers are to be believed as a realistic solution to the problem of sustainable consumption, the gap that exists between the sustainable consumers' intentions and the actual behaviours that they engage in must be explained. In recent years, there has been a substantial rise in the popularity of ethical consumerism. Because consumers claim to be ethical and environmentally conscious, but are not necessarily so when they make a purchase, there is less sustainable consumption than the records would show. That is the range that exists between the views, plans, and actions that an individual has vocally articulated. Customers who shop sustainably are concerned about the consequences that their purchases may have on the environment, society, or other aspects of the world; as a result, their shopping selections are influenced by these moral principles. Nonetheless, being ethical presents its practitioners with their own set of difficulties and worries.

There are additional studies that take the position that a consumer's goals are reflected in their ethical and ecologically responsible shopping patterns. According to a number of studies, the intention of customers to make a purchase does not always convert into the consumer actually making the buy. It is crucial to keep in mind that both personal and societal circumstances can impact people's real purchasing behaviour, thus the intentions may not always be what they appear even if many recent research have come to the conclusion that people's ethical intentions can be believed. In addition, integrating ethical considerations into day-to-day activities can be difficult and time-consuming. For an individual to behave ethically, it is necessary for both their internal and external environments, as well as their understanding of ethical concerns, to be in harmony with one another. The habitual planning and use of ethical consumption practices have been made easier as a result of making these practices less time-consuming and more readily available. The first step in the process of planning is to locate information that is pertinent to the endeavour. After that step has been completed, the plan can be developed and put into action. When consumers do not give significant consideration to their shopping habits from the beginning, it makes it more probable that they will make compromises and unethical purchases in the future. It is not easy to switch from unethical shopping practices to more moral ones, just as it is not easy to switch from negative behaviours to positive ones. It is vital to break old shopping habits to form new shopping routines in order to shop in a consistent and moral manner.

In conclusion, the dissemination of information to customers on ethical consumption and choices is not likely to result in a reduction in the purchase or use of unethical items or a shift in consumer behaviour. It is not enough to simply make information available to consumers; they also need to have a feeling that they are responsible for their actions. Responsible businesses may provide ethical products and engage in transparent business practices, but it is ultimately up to conscientious consumers to select items that adhere to ethical standards. It is important that a person's intentions match their actions, but this can only be achieved if consumers progressively become more ethical and sustainable through the thoughtful planning of their purchases and a transformation in lifestyle. The current climate of the fashion business is indicative of the fact that emotional impulses are more powerful than rational motivations. This fact highlights the necessity for ethical products to appeal to the emotions of consumers to motivate them to engage in more ethical behaviour.

7 Sustainable Fashion and the Fashion Labels

The phrase 'sustainable fashion' has become a common catchphrase in the fashion business. It does not suffice to follow the current fashion of socially responsible businesses making environmentally friendly items or about developing certain policy measures; it is about satisfying the requirements of forward-thinking buyers who wish to adopt sustainable fashion. As a result of consumers' increased knowledge of the manufacturing procedure and the materials used, there has been a rise in the demand for apparel that adheres to strict ethical standards.

The phrase 'sustainable fashion' has risen to prominence in the industry as a whole in recent years. Keeping up with the increasing trend of socially conscious businesses offering eco-friendly product lines and trying to adapt regulations to accommodate them is a key component of eco fashion. Consumers nowadays are pickier than ever before, constantly on the lookout for new wardrobe staples that not only match their ethical standards but also their budgets. As the term 'fashion sustainability' rises in popularity, fashion brands are re-evaluating their methods of production and adopting greener practices in an effort to distinguish themselves from the competition. Increasingly, conscious shoppers are buying from brands that care about the environment and treat their workers fairly. The number of people who actively seek out sustainable brands that care about the environment and employ eco-friendly strategies is growing. Brands are taking many different approaches to sustainability, and shoppers are becoming increasingly interested in making conscientious purchases. In recent years, the fashion sector has undergone spectacular transformations in terms of sustainability.

The fashion business is the second most wasteful sector worldwide (Mahajan, 2012), producing an estimated 1.5 million tonnes of trash annually. Consumers have come to expect sustainable clothing from all segments of the fashion industry as awareness of the environmental damage caused by fast fashion grows (Zhao et al., 2014).

8 Sustainable Design Techniques

Second Hand Shopping (Pre-loved, Low Cost) The trend of shopping at thrift stores and vintage shops has grown in recent years. The average consumer these days gives a lot of thought to what they buy. They know that used goods are not always a step down in quality from brand new ones, so they can save money without sacrificing quality. Finding one-of-a-kind, reasonably-priced clothing and honing one's own sense of style are both possible in thrift stores. NGOs and charity centres are essentially becoming the testing ground for large quantities of absolutely awful fast fashion items that cannot ever be resold, which provides yet another reason to encourage second hand shops while rolling back our tendency towards rapid fashion.

There is no risk of showing up to a party wearing someone else's clothes if you shop at a vintage or consignment boutique because of the one-of-a-kind nature of vintage and pre-owned garments. There really is not a single drawback to investing in vintage garments. The fact that it also aids in environmental protection and revolutionises the fashion industry is icing on the cake.

Custom Made/Produced-to-Order (Future Proofing, Re-thinking) Primarily, the apparel should indeed be created to order, using high-quality components and a timeless design that will stand the test of time while still being gentle on the environment. DIY projects are a part of this eco-friendly aesthetic.

Although it is a step in the right direction, this is not the kind of sustainable clothing one will see or wear every week. This is not a guarantee, but it is one way to ensure that the person who made your clothes was paid a living wage and had safe working conditions. Getting an item of clothing made to order allows the customer to have input into every aspect of the design process, increasing the likelihood that they will receive an item of clothing that they will treasure for years to come. Custom clothing orders are a great way to avoid contributing to the fast fashion industry while still getting a high-quality, timeless wardrobe staple.

Fair & Ethical Fashion (Free of Human Exploitation, Respecting Human Rights) The standard for environmentally friendly clothing is an item that benefits both the people who make it and the people who use it. Fair treatment of farmers and factory workers, conservation of natural resources, and improved quality of life for rural residents are all hallmarks of sustainable fashion. Urban Austral is a Patagonia-based company that provides upcycling jobs to locals and sells products made entirely from recycled materials.

Fair and ethical fashion inherently play a crucial role when discussing the various forms of sustainable practices in fashion as social evolution is one of the three pillars in sustainable fashion. Choosing to purchase garments that were produced in a just and ethical manner is the cornerstone of the fair and ethical fashion movement. All employees along the supply network must be treated fairly. Having total inclusivity about the work-settings of the folks who created your clothing is also important. This is an essential aspect of sustainable fashion to keep in mind.

Repair, Redesign and Upcycle Fashion (Upgrade the Quality, Beginning to Next Stage of Lifecycle) Reducing the negative effects on the environment that the fashion industry has by engaging in practices such as repair, redesign, and upcycling can be greatly aided by the design process. To 'upcycle' means to 'repurpose' something so that its new value exceeds the original value of the discarded material. Upcycling involves reusing materials that would have otherwise been discarded to create something with enhanced functionality while reducing waste, as opposed to recycling, which typically involves the chemical restoration of substances to produce a completely new product. Reconstructing previously worn garments or finished apparel into new items is one method of upcycling. Pattern cutting, draping, smocking, and knotting are all zero-waste design practices that reduce waste before manufacturing even commences.

To put it simply, recycling is the practice of repurposing materials that would have otherwise been discarded as garbage. Plastic bottles are one such instance. Most individuals are aware that our oceans are clogged with plastic, but some clothing companies are now collecting this trash and recycling it into new products such as swimsuits and sunglasses. However, upcycling does not involve reducing materials to their component parts to create a new product. It refers to the process of giving a previously used material or object a new function. It is like if your favourite pair of jeans got a hole in them, but instead of throwing them away, you decided to turn them into shorts.

The most obvious forms of sustainability in the fashion industry are recycling and upcycling, which make use of already existing materials. Reusing previously manufactured goods saves energy and natural resources that could be put toward creating something new.

Collaborative Consumption (Leasing, Gifting, Sharing): Excessive consumption and a non-recyclable culture are significant factors to the issue of increasing textile waste. 'Collaborative consumption', which encourages item reuse and prevent unnecessary future purchases, is gaining popularity as a means to reduce the amount of fabric wasted annually. Sharing, renting, and bartering are examples of the 'alternative consumption' economic and social model. The production costs can be shared amongst customers, lightening the ownership burden (Lang & Armstrong, 2018), and customers can aid in the fight against textile waste.

Nowadays, one can rent anything from a designer handbag to a nice sweater to an evening gown at any number of pop-up concept stores. Rather than going out and buying all new clothes, users can give the impression that they have a fresher wardrobe by simply doing this.

Waste Management (Educating the Masses, Improve Energy Production, Create Jobs) Shoppers might not actually realise that much of their closet is made out of plastic, which poses an issue for solid waste. Synthetics account for over 60%, and they can easily be disguised as natural fibres such as silk, cotton, or plush faux fur, or blended with organic materials to improve efficiency and reduce costs. However, consumers are cognizant of the fact that trash is piling up in the oceans around the

globe. The New Delhi-based ethical fashion company Conserve India has paid waste pickers for all kinds of plastic debris, turning it into belts and wallets sold in fair-trade shops all over the world.

9 Consumers' Changing Attitudes Toward Sustainability

The 'attitude-behaviour gap' is a phenomenon that is frequently noticed in sustainability contexts; nevertheless, the transition framework can assist in bridging that gap. Customers might claim an interest in environmentally friendly procedures (Trudel & Cotte, 2009), but that does not mean they are always ready to take action (Auger & Devinney, 2007; Gatersleben et al., 2002; Kollmuss & Agyeman, 2002; Young et al., 2010). The largest obstacle for businesses, governments, and non-governmental organisations (NGOs) who are attempting to encourage sustainable consumption is the disparity that exists between consumer rhetoric and actual behaviour (Johnstone & Tan, 2015; Prothero et al., 2011).

There is opportunity to further encourage and enable sustainable consumer behaviours, despite the fact that customer demand for environmentally friendly options is on the rise (Gershoff & Frels, 2014). For instance, 66% of consumers globally (and 73% of millennials) report being willing to pay extra for greener products. When the author refers to 'sustainable consumer behaviour', they mean any action taken by a consumer that lessens the product's or service's negative effects on the environment and/or its consumption of natural resources over the course of its entire lifecycle. 'Sustainable consumption' is another term for 'sustainable consumer behaviour'. Despite the fact that we are committed to environmental sustainability, it is necessary to keep in mind that, in accordance with an inclusive definition of sustainability (Norman & MacDonald, 2004), successes in this area can have far-reaching advantages. To provide more ecologically friendly outputs, the author investigated the entirety of the consumer process, from initial research to final disposal. A sustainable consumer behaviour includes, but is not limited to, the following practices: voluntarily reducing consumption; selecting products with responsible sourcing, manufacturing, and attributes (Luchs et al., 2012; Pickett-Baker & Ozaki, 2008); reducing energy, water, and product consumption while in use (Lin & Chang, 2012; White et al., 2014).

Case Study 1: H&M AB (Hennes & Mauritz)

Fast fashion brand based in Sweden
Established in 1947
Founder: Erling Persson
(Source: www2.hm.com)

About the Brand

Originally known as Hennes, the store catered exclusively to female customers. Norway is the site of the first location outside of Sweden in 1960. Erling Persson, after working in the industry for just over 20 years, made a wise investment in 1968 when he purchased Mauritz Widforss, a retailer of men's clothing and outdoor gear. As a result, the company rebranded as Hennes & Mauritz and expanded into selling apparel for men, women, and children. H&M was founded in 1947 and listed on the Stockholm Stock Exchange the following year; over the next two decades, the company expanded to markets all over the world, including those in Germany, the Netherlands, Belgium, Austria, Luxemburg, Finland, and France (H&M History, 2018).

H&M's first stores in the United States and Spain both debuted in the year 2000. H&M expands into new European and Asian markets in subsequent years. Karl Lagerfeld debuted the first collection of its kind. Many more partnerships blossomed from the initial one. Year 2007 sees the launch of the H&M Conscious Foundation, a worldwide charity run by the company. H&M purchases Fabric Scandinavian AB, owner of the brands Weekday, Monki, and Cheap Monday, and launches a new brand called COS the following year (H&M History, 2018). In 2010, H&M debuted its first 'conscious collection', made from eco-friendlier materials (H&M History, 2018).

H&M, COS, Weekday, Cheap Monday, Monki, H&M Home, & Other Stories, and ARKET are just some of the names that make up the H&M group, one of the most successful fashion conglomerates in the world. Karl-Johan Persson is the current president and CEO of the company. The Swedish capital of Stockholm is home to H&M's global headquarters. There are approximately 171,000 people working for the H&M group across its 4739 physical and 45 virtual stores in 2017. The company generated 232sek billion in sales (before VAT) in 2017 (Annual, 2018).

H&M's core belief is that 'Fashion and quality at the best price in a sustainable way' can be achieved. They hope that in the future, everyone will be able to afford to wear fashionable clothes that are both environmentally friendly and well-made. H&M recognise the importance of sustainability, so the company dedicates substantial resources to improving sustainability (SUSTAINABILITY, 2018). With more than 4856 locations worldwide and a massive online presence, H&M is a major player in the fast fashion industry. The brand has recently made the decision to adopt a greener and more environmentally conscious strategy. The Swedish conglomerate's fashionable collections and reasonable prices make it a top pick among young consumers.

H&M Value Chain

From initial concept to final disposal, the H&M value chain outlines the sequential steps that go into making a product. The socioeconomic, ecologic, and financial effects along the value chain are interconnected and substantial. H&M seeks to optimise the positive influence and minimise the adverse effects all along value chain to get the most out of their business idea. The following analysis is taken from the (SUSTAINABILITY, 2018). It identifies seven stages in the H&M value chain:

Design

Style that does not skimp on sustainability (in terms of design, quality, cost, or longevity) is the first step toward creating a truly circular economy. Both the environment and the people who make and wear clothes are affected by H&M's material and design decisions. H&M is making the decision to use sustainable materials and reduce waste in an effort to lessen the negative and increase the positive effects.

Raw Materials

Cotton, for example, requires a lot of water and chemicals to process, and this industry is notorious for its poor working conditions. H&M makes the most of its raw materials by selecting and utilising sustainable raw materials and striving for a 100% circular economy.

Manufacturing of Yarn and Fabrics

When making textile and yarn purchases, business partners should think about the impact on water usage, chemical usage, greenhouse gas emissions, and employee welfare. Unlike some competitors, H&M does not work with mills directly. H&M collaborates with environmental groups such as the World Wildlife Fund and the Swedish Textile Water Initiative (STWI) to address this issue and assist mills in making necessary improvements. Around 60% of H&M's products are made in collaboration with fabric and yarn mills, and these mills have already been integrated into the company's supplier assessment systems.

Manufacturing of Products

More than 60% of H&M's business partners are women, and they account for 1.6 million jobs in product manufacturing. Critical human rights concerns include: living wages, freedom of association, respectable working conditions, and a manageable schedule. Workers' rights to a living wage, freedom of association, respectable working conditions, and a manageable schedule of work are all critical components of social security.

Transportation

Transportation accounts for about 2% of GHG emissions; picking the right mode of transportation can bring that number down even further. H&M can have an impact on the transportation industry with regard to environmental consciousness and responsibility.

Sales

There are more than 4700 H&M retail locations around the world. There will be new hires at H&M as the company expands. H&M is making efforts to be a good corporate citizen by providing a stimulating and safe workplace for their employees. Customers have a right to expect high-quality goods and services when they make a purchase. Data privacy is important to H&M, and the company makes an effort to advertise and promote products in a responsible manner.

Use

Of all greenhouse gases, 20% come from people using and caring for their clothes at home. Making fashionable clothing that is both eco-friendly and socially

responsible has become a pressing issue in the present. H&M's goal is to encourage customers to be more conscientious about the care of their clothing and to provide convenient means for this to not result in the disposal of clothing items in landfills.

Sustainability Vision and Plan

The H&M group's 2016 Vision and Strategy reflects a shift in the company's conscious commitments and three aspirations, which are as follows: 100% leading the change; 100% circular & renewable energy; 100% sustainable fashion.

1. *100% Leading the Change*

H&M's mission is to serve as a force for positive change within the entire clothing sector. The aim of this meeting is to facilitate discussion amongst business partners on existing problems and potential solutions. Their mission to catalyse change in the operations and the industry as a whole can be broken down into three key areas (SUSTAINABILITY, 2018):

Innovation – New ideas are essential for completing the virtuous circle. H&M is helping pioneering businesses such as re:newcell, Worn Again, Thread and Sellpy, and Treeto textile to achieve this.

Transparency – Transparency in the supply chain is essential for establishing credibility, inspiring trust amongst trading partners, and empowering consumers to make more environmentally responsible purchases. There are two primary ways in which increased openness will drive the transition toward more sustainable industry; open and honest data sharing and Transparency Across the Industry: A Collaborative Effort.

Rewarding sustainable behaviour – H&M thinks it is more important to encourage and empower sustainable actions all along the value chain rather than just reward the ones at the end. Motivating people with rewards and incentives is an effective way to bring about lasting behavioural improvements. H&M has developed a variety of incentive programmes to recognise and motivate its business partners, employees, and customers who have been instrumental in driving change.

2. *100% Circular & Renewable*

Assuming that the world's population keeps growing at its current rate, retail sales of clothing will increase from their current level of 60 million tonnes to 160 million tonnes by the year 2050. Natural resources used by the fashion industry to continue producing goods and running at current levels are dwindling rapidly. To serve its customers better, H&M Group is transitioning from a linear to a circular business model. Maximum resource utilisation and minimum waste are achieved through the adoption of a circular model by keeping resources in use for as long as feasible before regenerating them into new goods and materials. As a result, less garbage will accumulate and fewer adverse effects will be felt. H&M's business model is shifting from linear to cyclical. This can be accomplished by incorporating circularity into the product's entire lifecycle, from the initial idea to the final disposal. H&M is concentrating on the five points of the value chain to achieve its goal of circularity (SUSTAINABILITY, 2018), namely Style, Material Use, Methods of manufacture, Usage of Product, Reusing and recycling of products.

To be considered truly circular, a business model must use only renewable energy sources. H&M's goal is to power its entire value chain with renewable energy, which will have a hugely constructive impact on the atmosphere.

3. *100% Fair and Equal*

The H&M group is committed to treating all employees, suppliers, customers, and other business partners fairly and equally. Achieving complete fairness and equality necessitates ensuring that our values and respect for human rights are supported by management at all levels of the organisation and throughout the entire value chain. H&M's efforts toward achieving its goal of 100% fair and equal focus on two fronts (SUSTAINABILITY, 2018):

Equal Employment Opportunity: A fair workplace is one in which all employees are valued and heard, and in which they receive equitable pay and benefits. This ensures that everyone in the company is treated with dignity and respect; both Within H&M group & Within Supply chain.

Act as a guardian of diversity and inclusion: H&M connects with and represents a large and varied population of people all over the world through its relationships with its employees, business partners, and customers. H&M is committed to a culture in which everyone is valued equally.

With the goal of being good stewards of diversity and inclusion, the H&M group strives to be open to and representative of people from all social classes. When it comes to the company's internal culture, they serve as guardians of diversity and inclusion by welcoming, accepting, and celebrating all employees and individuals. They advocate for diversity and inclusion in the world at large by interacting with consumers through worldwide marketing campaigns and product lines that highlight and celebrate the inherent worth of all people and their right to be themselves with no fear of judgement. In the H&M group, 90% of workers agree that everyone is treated equally regardless of age, gender, race, religion, sexual orientation, or physical ability. In 2017, 76% of all H&M group employees were women, with an additional 72% filling positions in management. H&M Created international standards for accommodating an ageing workforce. The recommendations encourage a proactive method of dealing with employees' ages in the workplace. The ratio of women to men on the board of directors was 56–44.

Sustainable Initiatives Taken by H&M

H&M strives constantly to improve its sustainability initiatives to maintain its position at the leading edge of the sustainability industry. H&M is committed to continuous, sustainable change, which is achieved in collaboration with stakeholders, employees, and business associates. H&M's goal is to be the sustainable innovation leader in the fashion industry, so the company started recycling old clothes as a standard practice. A worker at one of their manufacturing sites engages in a free and open discussion with the factory owner about his or her pay and working conditions (SUSTAINABILITY, 2018).

While H&M's recent initiatives in this area may seem like a fad-driven attempt to cash in on consumer interest in eco-friendly products, the company actually began its transition to sustainable practices in the 2010s (as mentioned below) and is racing to meet its goal of being completely carbon neutral by 2040:

2010 H&M introduced its first environmentally conscious collection and, along with Levi Strauss & Co., mandated a worldwide end to the use of sandblasting in the production of all of their goods. When someone joins H&M, they go through a training programme where they learn about the company's initiatives, goals, and problems related to sustainability.

2013 H&M launched its Garment Collecting programme with the goal of reusing and recycling of clothing.

2015 The Global Change Award was established by H&M to encourage new ideas and designs that will help the fashion industry move from a linear to a circular model.

2016 H&M also took action regarding wages in 2016. The goal from the beginning has been to ensure that everyone employed in the textile industry is able to survive on their earnings. Our Code of Conduct explicitly states this as well. The r new plan of action is predicated on the principle that all the industrial goods distributors should provide their employees with a fair wage that meets their basic needs.

2018 H&M believes its key suppliers will give staff a decent wage. H&M's guidelines should facilitate this, given it relies on a trained workforce whose pay are negotiated and evaluated annually by organised labour or employee representatives. H&M, industrialists, factory workers, and authorities take the pay question to the next level in fashion. The company rejects arbitrary goals. Employers and employees should negotiate a reasonable salary. It varies by country and factory. Giving workers the power to set and negotiate their own living salaries prioritises their needs over corporate profit.

2019 H&M joins a chosen group of companies that disclose information about their products' ingredients and production process.

2020 H&M topped the Fashion Transparency Index compiled by Fashion Revolution. H&M introduced Looop, a garment recycling machine with a focus on sustainability that can transform used clothing into new garments.

2021 A sustainability linked bond was introduced with great success. H&M has announced that they will collaborate with Maisie Williams as Global Sustainability Ambassador to spearhead a global push towards a more sustainable fashion economy. Williams and H&M will be teaming up to 'close the loop' in the fashion business by advocating for the repurposing, recreating, and recycling of old clothing.

Case Study 2: Stella McCartney

Sustainable luxury designer
Environmental activist based in Milan, Italy
Established in 1947
Famous for no-leather approach; uses vegan alternatives instead
(Source: www.stellamccartney.com)

History

In October 2001, Stella McCartney and the high-end Kering group formed a partnership that would see Stella McCartney's eponymous label come into existence. A devoted advocate for animal rights, Stella led the charge for cruelty-free fashion by omitting all animal-derived materials from her collections. She acknowledged that it was challenging to create without the typical tools and materials, but said that she had eventually found viable substitutes. Her organisation had demonstrated that long-term success was possible without sacrificing ethics. The Kering Group and other industry players were triggered by Stella's initiatives. If and how the fashion industry would scale up her sustainability drive remained to be observed.

In 2001, she held her first women's ready-to-wear fashion show in Paris and her first store in New York City. This expansion into new markets strengthens the recognition of a company that has rapidly expanded its product line to include ready-to-wear (RTW) for men and women, accessories, high-end lingerie, sunglasses, fragrances, and a trend among children.

In a short period of time, the label became a go-to for affluent, fashion-forward consumers thanks to its signature pieces, which include oversized sweaters, slim jeans, and vintage tees, and which are a perfect blend of tough-girl cool and ladylike sophistication.

The daughter of the ex-Beatles has been a true pioneer in ethical and sustainable fashion, constantly developing new materials such as vegetable leather, sustainable viscose, and recycled fibres (e.g. Falabella handbag launched in 2010 in vegetable leather or its KOBA vegetable fur of the FW20 collection). Stella McCartney, from its inception as part of the Gucci group, has been a symbol of ethical fashion and compassion for animals.

Sustainable Engagement

Stella McCartney is always looking into new ways to become more sustainable and adapt to the new economy because it recognises that it must account for the resources it consumes and the effects it has on the environment. The manufacturing process is the link between the product's conceptualisation and its eventual retail availability. Supply-chain management is a part of this as well. Consistent with its values as a responsible, honest, and cutting-edge business, the brand is dedicated to sustainable development, which is reflected in each and every one of its collections.

In the United Kingdom, Stella McCartney uses wind energy to power all of its stores, offices, and studios. Elsewhere in the world, the company relies on renewable energy to power its retail locations and administrative hubs; overall, 45% of the

company's operations are powered by renewable, eco-friendly sources. In a similar vein, Stella McCartney makes great use of organic cotton in her collections and is constantly looking for new eco-friendly materials and production methods.

The company's guiding principle of recycling is central to company's mission. They recycle everything that can be reused, which amounted to 34.3 metric tonnes in 2012; specifically, they recycle all textiles. Plus, recycling is available at each Stella McCartney store.

Stella McCartney was the first luxury goods company to contribute to environmental initiatives by participating in the Natural Resource Défense Council's Clean by Design Programme. With a 'focus on improving process efficiency to reduce waste and emissions and protect the environment', Clean by Design is an initiative with a similar goal.

The production of textiles has a major impact on the environment because it uses a lot of energy and water, produces a lot of waste, and pollutes the water supply at a rate of about 200 gallons per tonne of fabric. This programme has as its goal the saving of about 25% of water and 30% of energy.

Stella McCartney uses novel methods all along the supply chain and in her designs to minimise her company's negative effects on the environment. No leather or fur is used, reflecting a contemporary and eco-conscious aesthetic. The company has begun using sustainable viscose and regenerated cashmere instead of virgin cashmere in an effort to reduce its environmental impact. The publication of the company's first annual worldwide Environmental Profit and Loss (EP&L) report for 2015 was also a major step forward for the brand's environmental mission.

Environmental Profit and Loss

An organisation's environmental impacts, both positive and negative, can be quantified and monetised through the use of natural capital accounting techniques such as the Environmental Profit and Loss (EP&L), which is applied to the entire business, not just the company's direct operations. It is a cutting-edge tool that helps Stella McCartney go beyond conventional environmental reporting to make informed choices. Stella McCartney uses it to guide its industrial design, procuring decisions, factory production, and R&D, and it provides the company with a clear, measurable knowledge of its effects on the environment.

Carbon dioxide emissions, air pollution, water contamination, water usage, waste, and changes in ecological systems linked to land utilisation are all factors considered in the EP&L analysis of Stella McCartney's entire supply chain and operations, from raw material production to final customer disposal. Stella McCartney is proudly cruelty-free that never used leather, fur, or skins in any of its products. Stella McCartney has always stood by this choice, which she says was made for ethical and environmental considerations. The environmental impact of leather has been further highlighted by the earnings and profit and loss statement (EP&L) for the larger Kering business, which does use leather. This made it possible to directly compare the effects of the artificial materials used by the brand to the effects of leather use through the EP&L.

The energy and water need of tanneries, as well as the property use and emissions of greenhouse gases from animal husbandry, are the primary contributors to the environmental costs of leather production. Stella McCartney joined forces with the non-governmental organisation Canopy in 2014 and pledged to have all of its cellulose fabrics (viscose) comply with stringent sustainability standards by 2017.

Stella McCartney was concerned that the fabric components of her company's products might have come from unsustainable sources such as the destruction of rare and ancient forests. Stella McCartney has delivered on this promise with her Spring 2017 collection. All of the brand's viscose for ready-to-wear originates from Swedish forests that have been certified as environmentally friendly, is refined in Germany, and is woven in Italy, creating a completely European supply chain.

Sustainable Initiatives Taken by Stella McCartney
(Source: www.stellamccartney.com)

2001 It became a policy to never use any kind of animal skin, fur, feathers, or leather.

2008 Initiated use of organic cotton.

2010 Totally phased out the use of PVC.

2012 Stella Eyewear began using bio-acetate, recycled polyester was introduced, Clean by Design was implemented in Italian factories, plastic water bottles were outlawed, and all of wood was certified as sustainably sourced. She also joined the Ethical Trading Initiative (ETI).

2013 Phased out angora, debuted sustainably sourced 'eco-Alter Nappa', installed solar panels and light-emitting diodes (LEDs).

2014 Adopted a policy of only using sustainable paper and cardboard for all kinds of packaging.

2016 Saw the company switch from using virgin cashmere to 100% sustainable viscose.

2017 Introduced Econyl® regenerated nylon and released the first garment made with Bolt Threads' Microsilk™.

2018 Barred the use of mohair, introduced the Loop sneaker, pledged to use no plastic, debuted a vegan version of the Stan Smith shoe, and produced the first handbag made from Bold Thread's Mylo™—a mushroom leather.

2019 Adidas by Stella McCartney released the first-ever clothing items crafted from Evrnu's NuCycle™ yarn and KOBA® Fur Free Fur, a sustainable, recyclable animal alternative crafted from reprocessed polyester and plant-based plastic.

2020 Launched Stellawear, a sustainable innovation fusing underwear and swimwear, made from Aquafil Econyl® regenerated nylon and ROICA™ elastane; debuted Coreva™ biodegradable stretched denim; bio-lenses in Stella McCartney eyewear; bio-acetate frames in Stella Kids eyewear; and ROICA™ elastane.

2021 Air Slides, released as part of the Summer 2021 collection, will be made from recycled materials excised from the factories that produce them.

10 Conclusion

When designing new clothing, fashion designers have to think about not only how the garments will be manufactured, but also whether the finished product will be something that consumers will want to wear on because of the socially conscious message it conveys. Fashion is a form of self-expression that may be applied everywhere in the world. Customers are concerned about the ethical standards that were upheld during the production of their purchases, and this extends to the apparel that they buy as well. Today, ethical practices embrace the significance of paying fair wages and maintaining a positive work environment, both of which are selling points. Making the transition to a more ethical fashion alternative needs some advanced planning, but it is well worth it when one considers issues such as the protection of factory workers in less developed nations and the well-being of the planet itself. It is vital that ethical fashion be widely pushed to ensure a future that is both safe and healthy while also being sustainable. Everyone involved in the manufacturing and retailing of a product has a responsibility to protect the environment throughout the entirety of the product's life cycle, beginning with the suppliers of raw materials and ending with the consumer who buys the finished good. If we want to truly flourish and prosper, we need to place a high value on the heritage of our traditional crafts and the natural environment. Short-term benefits may be obtained through unsustainable practices, but overall, these practices will always come back to haunt us.

It is essential to integrate sustainable practices into every aspect of business to get a competitive advantage in the fashion industry, which is notoriously cutthroat. Because both the internal and the exterior surroundings are always shifting, it can be challenging to make decisions in both of them. This research is being used as a foundation by other fashion businesses and industries as they work to develop their own sustainable integration projects. The main goal of this chapter is to help the reader understand how to integrate sustainable practices throughout the entirety of an industry's value chain, which includes all operations, both internal and external. If this is done, the sustainable performance will increase, and more collaboration with stakeholders all over the world will be fostered. This chapter provides evidence that there is a correlation between the growth of fashion market and the concept of environmentally responsible business practices. The author believes that a source of

competitive advantage can be found in environmentally friendly, socially responsible, and economically advantageous characteristics of a product.

Customers who have only lately begun to be concerned about the environment will continue to expect that companies that specialise in rapid fashion adhere to this criterion. Companies who fail to adapt their offerings in response to the seismic shift in the tastes of their target demographic will quickly become obsolete. Since it is anticipated that the significance of sustainability will continue to increase in the years to come, businesses who begin to include it at this time will have a greater chance of recovering and either maintaining or expanding their market share, brand image, and revenues. Because of the pandemic, customers' tastes are shifting, and the fashion industry as a whole need to make the transition towards more sustainable practices so that it can represent those shifting tastes and appeal to those consumers. However, fast fashion is the industry that causes the greatest damage, and as a result, its executives need to rethink their traditional approaches to mass producing garments and be more honest about the practices they employ in their opaque supply chains. Businesses operating in the fast fashion sector, as well as those operating in the broader fashion industry, need to be more forthright with their customers. This can be accomplished by disclosing information about the sustainability practices that the businesses engage in and by adopting circular business models. Once circular business models become the major source of raw materials, production of cotton and synthetic fibres made from fossil fuels may be reduced or abolished entirely. The shift toward greater sustainability during the post-pandemic restoration process is beneficial to the economy as a whole because it increases brand loyalty and revenue streams while simultaneously reducing the value lost from unused and excess clothing. This shift also helps to prevent further damage to the environment. Real style is something that can be handed down from generation to generation, while quickly generated trends never go out of fashion. Because environmentally responsible behaviours are here to stay, neither customers nor businesses can afford to ignore them any longer.

A rich vein of opportunity can be found in the rapidly developing quick fashion market of the apparel company. The enterprise's success can be attributed to a variety of variables; yet, these same elements also contribute significantly to the damage that it does to the surrounding environment. The United Nations General Assembly announced in 2019 that the world has until the year 2030 to prevent irreversible damage caused by climate change. This announcement came just 1 year prior to the start of the pandemic. When worldwide activity was eventually brought to a halt as a result of the pandemic, the globe finally started to show evidence that it was beginning to recover. The frenetic speed at which the fashion business operates needs to be slowed down. Simply said, the only thing that will push firms to extend their sustainable products and practices is demand from customers. The findings show that customers have altered their behaviour as a whole as a reaction to the unusual epidemic as well as stay-at-home orders. The desire for fast fashion has been affected by a number of factors, including the fluctuating discretionary incomes, preferences, and lifestyles of consumers. Because the global pandemic has caused a shift in customer expectations, the fashion industry as a whole need to make

advances toward greater sustainability to maintain its position as a competitive business.

The topic of whether our paradigm can be generalised to other behaviours such as healthy or helpful behaviour, or whether the characteristics are exclusive to sustainable behaviours, is an important question that has consequences for both practice and theory. Our working hypothesis is that a significant number of the components of our framework may also be transferable to the other desired behaviours. However, it is important to remember that sustainable consumption could involve its own unique set of considerations. This is a potential area for investigation in future research, and there is both theoretical and practical potential in extending the framework to a variety of different settings.

The author also explains that it is the responsibility of marketers to persuade customers that environmentally friendly products and services are more valuable than their traditional counterparts. As a result of green marketing campaigns, customers are more likely to pay a premium for environmentally friendly items. Finally, both individuals and corporations are making deliberate attempts to lessen the negative influence that they have on the environment. It would appear that in emerging nations such as India, environmentally conscious marketing is even more vital at this point in time. Consumers need to be made more aware of the benefits that come from purchasing environmentally friendly goods and services, and efforts should be made to bring this information to their attention. Last but not least, everyone who is a part of the supply chain, from consumers to industrial customers to suppliers, needs to be committed to lessening the negative effect that they have on the surrounding atmosphere. The results of the chapter specify that customers have a high level of knowledge, and their preferences change over the course of time. The only thing left for marketers to do is instruct customers on the most effective ways to use environmentally friendly products. Lastly, in this day and age of increasing digitalisation, the advertising of environmentally friendly items to consumers can take place on the Internet.

11 Scope

When it comes to sustainability, not everything is as simple as it seems. There are numerous standards that need to be attained, such as lowering one's impact on the surrounding environment and finding productive uses for discarded materials. The price of clothing that is made with organic raw materials, adheres to fair trade practices, and is managed with expertise which is more than the price of mass-produced goods. Because it is made to last much longer and gets better with each wash and use, clothing that is produced in a way which is kind both to the environment and to the people who make it can eventually pay for itself. Understanding of sustainable fashion is still in its infancy due to the fact that it has not yet reached the same level of popularity as rapid fashion. The necessary financial commitment is the most

significant detriment associated with choosing an environmentally friendly method. When compared to their less environmentally friendly counterparts, sustainable fashion products and materials typically carry a price tag that is significantly more. The increase in prices has manufacturers worried that families in the middle class will no longer be able to afford to buy garments.

This chapter explains that practitioners who are interested in convincing customers to adopt more ecologically friendly practices may receive beneficial insights from the shift paradigm. More research into ecological consumer behaviour, it claims, will be conducted as a result of this framework's provision. The research expects that the framework would inspire customers to begin engaging in more ecologically friendly behaviours and create a road map for sustainable enterprises to follow that will lead to both environmental and financial success. In this study, the shift framework is used to analyse the factors that prevent long-term changes in consumer behaviour and to make important theoretical assertions and research paths recommendations.

In reaction to the alarming situation of the environment, both consumers and businesses have begun to employ environmentally friendly products and services. Because they will help conserve vital resources, implementing these steps will be beneficial to both society and the environment. The purpose of this study was to shed light on this concept that is beneficial to the environment. At some point in the future, its application will increase even further. The preferences of consumers are changing, and it can be expected that this trend will continue in the future. Possible topics for investigation in forthcoming research include the gender gap in the understanding of environmentally friendly products. The influence that green marketing has on customers in rural areas can also be investigated through the use of an empirical study. At some point in the not-too-distant future, each and every company will have no choice but to begin stocking shelves with items that are beneficial to both people and the planet. If green goods and services are to have a future, business people selling them must be sensitive to the wants and requirements of their customers, do their best to satisfy those needs, and do so in a way that has as little negative influence as possible on the environment. More investment in R&D is necessary on the part of the textile industry.

For the textile industry to develop into an eco-brand, more resources need to be invested into R&D of various materials and technologies. As a result, time is a significant factor, which may work against them. It is necessary to obtain eco-friendly supplies and recruit staff members who are knowledgeable on how to use these materials. It is not always the case that customer acceptability and being comfortable with the price point are the most significant aspects. Additionally, consumers may have additional options to show their individuality as a result of the transition toward environmentally responsible clothes. Beyond the influence of fashion seasons and trends, sustainable fashion is likely to dominate the industry as a whole thanks to the synergy between brand innovation and local resources. This is because sustainable fashion minimises the use of non-renewable resources while simultaneously maximising the use of existing resources.

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Upcycling the Pre-Consumer Textile Waste into Inventive Accessories

R. Dhivya and B. Subathra

Abstract The fashion industry enhances a person's appearance by adding colour and levity. People enjoy dressing to make an impression on others and for their satisfaction, which encourages the production of rapid fashion, or inexpensive clothing. Fast fashion items are produced at a lesser cost and with lower quality. As a result, the fashion sector is considered one of the most polluting industries in the world. Waste management must be done correctly with the protection of the environment in mind. Pre- and post-consumer waste management may help to lessen environmental contamination. Pre-consumer waste refers to cutting department waste from a production unit, and post-consumer waste refers to apparel that has been thrown off by consumers. Pre-consumer waste is an unshaped cloth that is discarded before it reaches the hands of the consumer. Trial research of upcycling pre-consumer garbage into practical accessories is the concept of this study.

Keywords Accessories · Fast fashion · Pre-consumer waste · Upcycling

1 Introduction

Textile is one of the wonderful inventions of the human race, as it gives comfortable, supportive and protective life to the human kingdom. Textile is submerged with human life, opening eyes from bed to closing eyes on the bed, the whole day is completely sophisticated with the textile products. The need for textile products motivates the cultivation of its raw materials and the whole process increases the revenue of the people and the nation (Niinimäki, 2013).

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The textile is there in the form of a toothbrush, towels, dressing, home textiles, tissue, footwear, luggage, vehicle's inner lining, comfort clothing, protective wear, accessories etc. Import and export activities of the products increase the job opportunities in the nation. The quality was the main concern of certain products, the cheaper cost is also expected in some products. Where compromising the quality makes the products available at a cheaper cost. Bulk production and low-quality products lead to more wastage in the production process. Those production wastes are disposed directly to the land, without any further recycling. These landfills affect the quality of land and the life of microorganisms, plants and animals (Yalcin-Enis, 2016).

The fashion industry is more successful in the form of production, marketing and innovation in developing countries, but its footprints affect the environment.

2 Overview of the Textile Industry

The development of India's textile industry dates back more than 5000 years. Despite historically being an important part of commercial activity in ancient and mediaeval India, the contemporary textile industry in India was only established in the early nineteenth century by British companies. Bhilwara has been identified as India's top textile producer. It is known as the Textile City of India and is a well-known industrial town in Rajasthan.

In the nineteenth century, Manchester, England—also known as the 'Cotton polis' served as the hub of the British cotton industry. Manchester is known for being the world's first industrial city. The area was well known as 'Cotton City' (Wang, 2006). Gujarat is better known for its cotton textile industry. Ahmedabad, a city in Gujarat, has grown into a key centre for the production of cotton textiles and is sometimes referred to as the 'Manchester of India' since it is simple to obtain raw materials there and the climate is ideal for spinning and weaving. The neighbouring cotton fields and Coimbatore's sizeable textile industry have given the city the moniker 'Manchester of South India'.

China is the largest producer and exporter of textiles worldwide. Over the past 20 years, the Chinese textile industry has grown significantly and is now one of the main engines of the country's economy. Along with apparel, clothing accessories, textile yarns, and textile products, clothing is one of China's main exports. Maharashtra has the biggest concentration of cotton textile mills in India due to the state's easy availability of labour and traditional knowledge. This could be the cause of Assam's high level of handloom and weaving production in India. One of the finest artistic traditions in the world is represented by their exquisitely woven 'Eri', 'Muga', and 'Pat' fabrics (Agrawal et al., 2013).

One of the Top Textile and Garment Companies in India is Arvind Ltd., often known as Textile King in that country). The Indian government has assisted textile companies directly and indirectly. Raymond Ltd. With a capacity of 38 million metres in wool and wool mix textiles and a market share of more than 60% in India,

Raymond ranks among the top three fully integrated producers of worsted suiting globally. One of India's top garment producers is Raymond (Guner & Yucel, 2005).

3 Fast Fashion

Fast fashion is a term used to describe cheap, trendy, mass-produced apparel that has a large detrimental effect on the environment. These garments appeal to customers since they are fashionable and affordable. But because they are not long-lasting and rapidly go out of style, these clothes are easily discarded and end up in landfills.

A method for designing, developing, and marketing clothing designs that place a strong emphasis on giving customers quick and affordable access to the latest trends in fashion. Many buyers find Primark's enticing offer of stylish clothing for an unbeatable price to be irresistible (Sandin & Peters, 2018). Fast fashion has three essential qualities in the eyes of the consumer: it is inexpensive, fashionable, and disposable. It enables making impulsive apparel purchases easy and affordable. Shoppers are urged to regularly update their wardrobes throughout the year to keep up with the rapidly changing patterns.

Customers demand high-street businesses to have new, moderately priced, and fashionable items every week. The fast fashion industry is crucial to the global economy. It employs 300 million people worldwide. In the poorest countries on earth, it employs farmers and labourers (Lau, 2015).

Fast fashion is so reasonably priced because brands and retailers use low-cost, harmful to the environment production methods. It costs more to fund activities to assist the neighbourhood community and ethical production techniques.

The negative repercussions of fast fashion on society have drawn strong criticism. It does not support diversity, inclusivity, or fair treatment of women. Instead, they promote a hostile, violent, and prejudiced culture. According to The Ethical Consumer and Greenpeace's publication, 'Unearthed', if the demand for fast fashion keeps growing at its current rate, by 2050 our clothing might have a 26% overall carbon footprint (Sharma, 2020).

4 Textile Waste

Textile waste is created at every stage of the textile manufacturing process, including spinning, weaving, dyeing, finishing, creating apparel, and even at the consumer level. They can be divided into one of three groups: Comb, draw, and spin processes all result in the production of soft waste. By using biodegradable polyester fabric, textile waste and its environmental impact can be reduced. During manufacturing, a biocatalyst was added to the yarn to make the polyester component of the biodegradable fabric biodegradable (Sharma, 2020; Piya, 2020).

Products developed from post-consumer recycled materials have achieved their goals. Water bottles, utensils, and other consumer packaging are examples of waste that is kept out of landfills and is instead used to make new goods. Post-industrial rubbish is the term for garbage 'stuff' created after a production process, whereas finished commodities are referred to as post-consumer waste. This type of manufacturing waste is produced by almost every processing line, whether it is liner board used to create corrugated cardboard or metal used to create soda cans.

5 Types of Textile Fabric Waste

Waste textiles from pre- and post-consumer sources can be separated from one another. Selvedges and leftover fabric scraps from cutting and other garment-production processes are among the pre-consumer trash generated on factory floors (Hawley et al., 2013).

5.1 Pre-Consumer Textile Waste

Pre-consumer textile waste includes materials thrown away before they are used by consumers, such as fabric and garment samples, overstock, and fabric from roll ends, as well as materials that were thrown away before they were suitable for consumer use, such as fabrics with poor printing, dying, or finishing, or materials that are produced while products are being made (such as the pieces of fabric leftover after cutting out a pattern). Pre-consumer trash is the byproduct of recycling manufacturing waste during production. Pre-consumer garbage is frequently used in manufacturing industries, however recycling in the traditional sense is not always given to it. Normally, this garbage is clean (Chavan, 2014).

According to Lau, producing the same quantity of textiles from raw materials results in far greater environmental, health, and social harm than reuse and recovery of textile waste. Many of the energy- and pollution-intensive processes required to create textiles from virgin materials can be avoided by recovering fibres from textile waste. Since practically all textiles can be recycled, there should be no waste in the textile and garment industries (Wood, 2019). Therefore, recycling and reuse are crucial and must be addressed throughout the entire fashion supply chain (Fig. 1).

Pre-consumer waste, according to Hande Sezgin, includes goods created for sale and consumption that have design flaws, fabric flaws, or the wrong colours, as well as goods that are unsold and damaged in the retail industry. With the growth of the fashion industry, it is estimated that 10–20% of textiles are wasted during the production of garments.

Pre-consumer textile waste, as defined in the textile value chain, is waste material that is discarded before it reaches the consumer (such as fabric and garment samples, overstock, or fabric from the end of rolls), or that was discarded before it

Fig. 1 Pre-consumer waste in industry. (Courtesy: https://cleanclothes.org)

was ready for consumer use (such as defective printing, dying, and finishing of fabrics), or that is created while products are being manufactured (such as the pieces of fabric leftover after cutting out a pattern). Pre-consumer waste is created when manufacturing scrap is reincorporated into the production process. Pre-consumer trash is frequently employed in the manufacturing sector but is not always regarded as recycling in the conventional sense. Most of this trash is clean (Sharma, 2020).

Reusing pre-consumer textile waste within the fashion supply chain offers many environmental advantages, including:

- Directing waste away from landfill and incinerators.
- Conserving resources and providing a solution for the current shortages of natural resources and virgin fibres.
- Providing low-cost raw materials for fashion products.
- Delivering a lower monetary and environmental processing cost than virgin fibres (Clark, 2008).

According to Y Wang, damaged textile waste consists of unfinished textiles that have flaws in the colour or print, unfinished or finished garment waste that has not yet been used (Fig. 2).

6 Environmental Impact of Apparel Waste

According to Merve Kucukali-Ozturk, most nations are attempting to enhance recycling while reducing the amount of waste that is disposed of in landfills. Lack of enough facilities to process the enormous amount of trash produced in large cities, although there are ways to reduce textile waste; prevention, reuse, recycling, and the creation of energy from waste is generally favoured, and landfilling is the least preferred. The circular economy for a sustainable society heavily relies on the 3Rs (reduce, reuse, and recycle (Yalcin-Enis, 2016; Dilnot, 2009).

Fig. 2 Pre-consumer waste in fabric bundle ends. (Courtesy: http://socialalterations.com)

We should set an environmentally conscious goal to never throw away or discard textiles ever again because they are almost entirely recyclable and can potentially satisfy our requirements numerous times (Wang, 2006).

7 Waste Management

Waste management makes the best and most practical use of the disposal of goods. Analysing the composition and characteristics of the waste material, determining whether a demand exists, and identifying the ideal application field are all steps in the process of developing a creative, effective product. A successful product launch that attracts the target market is a good first step toward achieving sustainability (Evans, 1998).

7.1 Upcycling

Upcycling is the process of improving a product over its original form. This typically means taking dead stock clothes that do not fit, are stained, broken, or otherwise unusable and turning it into something that can be worn. Upcycling can be done with textile waste from the pre- or post-consumer and industrial phases as well as a combination of the three.

Upcycling can no longer be used to create more material items in a world that is already saturated with them. As a result, it creates distinctive, usually one-of-a-kind items from what many consider to be waste, reusing materials in new and imaginative ways that could otherwise wind up in the landfill. It gives old items such as ragged T-shirts and worn-out pants a new lease of life while also enabling businesses and designers to make better use of waste materials such as upholstery remnants or vintage linens (Evans, 2003).

With the help of upcycling, resources are preserved, carbon footprints are decreased, energy is conserved, and landfill space is spared. When you buy an item that was made from recycled materials, you directly offset the water and energy needed to produce equal new materials from scratch.

Textile trash that was produced before reaching the consumer is referred to as pre-consumer waste (Sharma, 2020). It is estimated that 10–20% of textiles are wasted during the manufacture of garments and that 5–25% of waste is generated for a single garment.

Pre-consumer waste includes products manufactured with design flaws, fabric faults of the wrong colour or shade printing, dyeing and finishing, holes, stains, distorted knitting, fabric and garment samples, overstock, fabric from the end of rolls, leftover fabrics, along with unsold and damaged products in the retail sector. Because it presents no collection or hygienic issues, pre-consumer trash is simpler to recycle than post-consumer garbage (Farrer, 2011).

Post-consumer waste is created by consumers' routine purchases, uses, and disposals of clothing or household goods, which typically end up in landfills. Compared to other categories of waste, post-consumer waste has a fairly big volume (Yalcin-Enis, 2016).

The fashion business places a high priority on waste management. There are five methods for treating garbage: disposal (landfill), energy recovery (waste to energy), recycling, reuse, and prevention (reduction). In which the circular economy for a sustainable society emphasises the 3Rs (reduce, reuse, and recycle) (Wood, 2019) (Figs. 3, 4, 5, 6 and 7).

According to the textile value chain, commercial and industrial textile uses, including commercial waste such as carpet and curtains, produce industrial textile waste. Generally, this trash is 'dirty waste'. The majority of these end-of-life products are either burned or disposed of in landfills. Companies may order 3–10% more than is necessary, and some luxury brands destroy their excess

Fig. 3 Textile swatch waste. (Wang, 2006; courtesy: http://socialalterations.com/)

Fig. 4 Cut and sew waste. (Wang, 2006; courtesy: http://socialalterations.com/)

Fig. 5 Sampling yardage waste. (Wang, 2006; courtesy: http://socialalterations.com/)

inventory to protect their reputation. Fabric that is defective because of mistakes in the printing, weaving, or colouring. Before apparel reaches the consumer, hundreds of thousands of tonnes of fabric are wasted during the design and production stages (Fletcher, 2008).

- It can enter the solid waste stream and end up in landfills or waste incinerators.
- It can be converted into energy to power the manufacturing process.
- It can be sold to a textile waste recycler.

Fig. 6 Clothing sample waste. (Wang, 2006; courtesy: http://socialalterations.com/)

Fig. 7 End-of-roll textile waste. (Courtesy: http://socialalterations.com/)

7.2 Design Perspectives in Upcycling

- To maximise the value of leather waste, Kushwaha and Swami created 30 distinct upcycle goods from leather scraps in 2016. These products include cushion covers, table mats, holders and folders, handbags, wallets, yokes, collars, earrings, and necklaces. Babies grow so fast that they can wear their clothes for only a very short time so Cara Sheppard, a Canadian crafter, launched an initiative in 2015, designing keepsake animal toys for families from their babies' old clothes (Fletcher & Grose, 2012).

8 Need of the Study

The best technique to utilise textile waste is the study's main topic. During the cutting of garments, the textile sector produces additional waste. Small fragments of irregularly formed cloth constitute the waste (Fuad-Luke, 2008). It cannot be used further for clothing manufacturing. Because of this, most industries discard it as garbage. It takes 10 years for this tiny scrap of fabric to break down. However, some fabrics are disposed of every day in landfills, which is harmful to the environment.

9 Justification of the Study

Taking a fresh approach to addressing the environmental impact is crucial. Start the small step to progressively lessen the impact. Therefore, a step is taken to repurpose the fabrics that the cutting department discards as functional accessories (Erlhoff & Marshall, 2021).

10 Pre-Consumer Survey

An organisation may utilise a consumer survey as a data-gathering technique to learn from customers about their experiences with both new and old products (Gill, 1998). Therefore, a pre-consumer survey was conducted to ascertain whether consumers support upcycled goods. A few sample products are listed, their approval is assessed, and a few consumers freely proposed a few products to make to learn about consumer acceptance. Additionally, the products' expected costs were examined. A limited number of product lists are scheduled to be produced based on user expectations and suggestions.

11 Product Making

The pre-consumer survey's findings serve as a wake-up call for creating the final product list. Therefore, it is proposed to make the products on the list below using pre-consumer waste fabrics.

1. Bell pin & needle holder
2. Headphone holder
3. Mobile phone holder while charging
4. Colour pencil storage bag
5. Coasters

6. Notebook pen holder
7. Spoon and knife holder
8. Corner bookmark

12 Product Execution

12.1 Bell Pins and Needle Holder

Bell pins are most frequently used for sewing together two pieces of cloth, such as the main fabric and the lining. The bell pin's safety is not given much consideration during construction. When cleaning, most of the bell pins are frequently overlooked and discovered on the floor. Professionals employ magnetic bell pin holders as a result. Here, as an alternative, pre-consumer trash is used to create a bell pin holder.

A pattern sheet, ruler, pencil, shears, marking chalk, thread, and ornamental button were the basic instruments utilised. Raw cotton varieties and nappy woven cotton fabrics were used to create the final product.

A circular pattern was created with a dimension of 10 cm along with an allowance of 0.5 cm. The pattern was traced over the nappy fabric and two pieces were cut and taken. The seam allowance lines were marked at the wrong side of the fabric and stitch was given through the seam allowance line and a small space was left to stuff the cotton. Small slashes were given in the seam to make the shape perfect and it turned inside and out, then smoothen the corners. Cotton is stuffed inside and the edges were finished with hand stitches. The bell pins and needle holder is decorated by using embroidery thread and button. This soft fluffy cotton stuffed ball is used to hold the bell pins and needle. Figures 8, 9 and 10 show the raw fabric, cut patterns and end product of bell pin holder.

Fig. 8 Nappy cotton fabric. (Source: Authors)

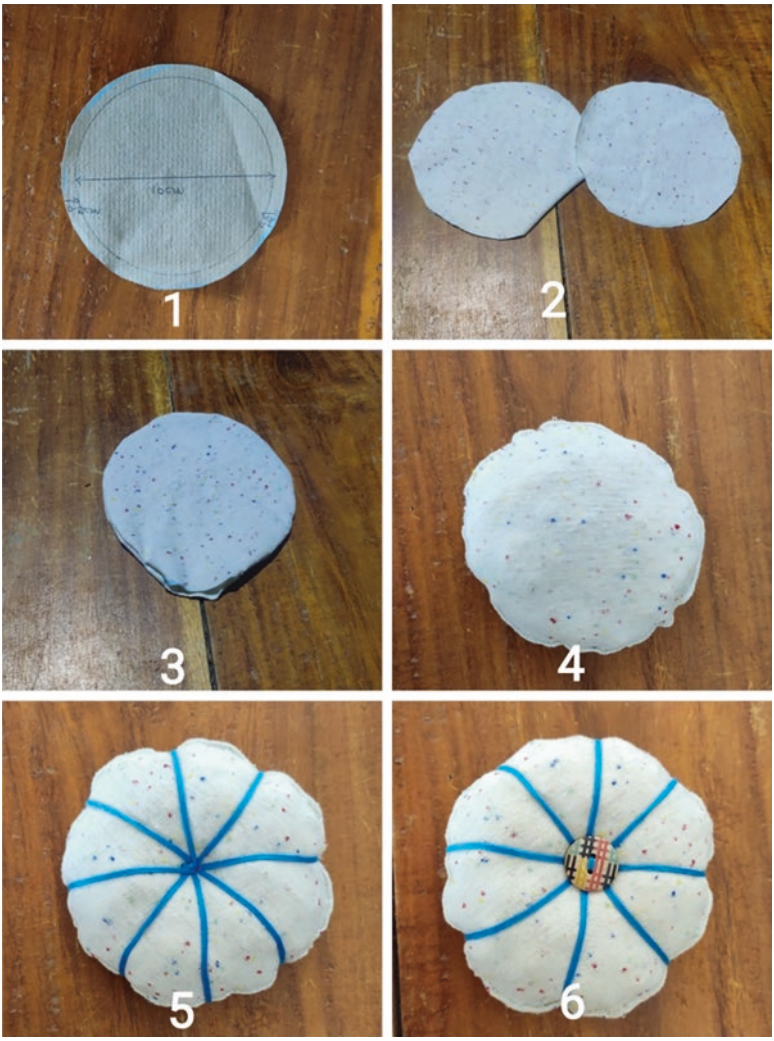

Fig. 9 Process sequence of bell pins and needle holder. (Source: Authors)

12.2 Headphone Holder

Mobile phones play a significant role in human existence. It is an integral part of daily existence. It started to resemble a piece of the human body. When people go out, they always handle it, but putting it in a handbag could harm this delicate electrical item. Carrying it in a soft pouch may therefore assist to increase its lifespan. So, using the extra fabric, a tiny headphone-carrying pouch was created. Along with the fundamental pattern-making tools, printed khadi fabric, cotton twill fabric, and canvas were also taken.

Fig. 10 Bell pins and needle holder. (Source: Authors)

One circular panel for the base and two moon-shaped patterns for the front were created based on the produced design that was chosen, and the fabrics were cut out following the prepared patterns. Canvas was also used to stiffen the product and secure the article within. The printed khadi fabrics used for the product's body are cut, and the plain twill fabric is utilised to pipe the raw edges.

A circular design with a 10 cm diameter and a 0.5 cm allowance is made, and another pattern in the shape of a half-moon is made from the same pattern. For the shell lining and fusible interlining, trace the patterns over the printed khadi fabric using the circular pattern cut number of 1 and the half-moon pattern cut number of 2.

Twill fabric is cut in bias with a width of 1.5 in. and the needed length to tie the corners of the headphone holder. The interlining is bonded to the cutouts in the shell fabric. Connect the fused shell fabric to the lining, then bind the prepared fabric corners with twill fabric to create a half-moon shape. Sew the three pieces together to create the desired shape, and then bind one corner of the headphone holder. Figures 11, 12 and 13 reveal the raw materials, making of pouch and ear phone holder.

Fig. 11 Printed khadi and twill fabric of cotton. (Source: Authors)

Fig. 12 Process sequence of headphone holder. (Source: Authors)

Fig. 13 Headphone holder. (Source: Authors)

12.3 Mobile Phone Holder While Charging

To bind the corners of the headphone holder, twill fabric is cut in bias with a width of 1.5 in. The cutouts in the shell fabric are attached to the interlining with a bond. Fuse the shell fabric to the lining, then bind the corners of the ready fabric with twill fabric to form a half-moon shape. After assembling the three components into the correct shape, tie one corner of the headphone holder.

The first part's patterns are made with dimensions of 31.5 cm in length, 13 cm in width, and a hole for attaching the charger to the switchboard. The second part's patterns are made with dimensions of 14 cm in length, 13 cm in width, and 1 cm in allowance for each of the two sections. To make the shell lining and fusible interlining, trace the patterns over the khadi fabric using cut number 1.

Twill cloth is cut on the bias with the necessary length and width measurements to tie the corners of the mobile phone holder while it charges. The interlining is bonded to the cutouts in the shell fabric. The second piece's corner is tied with twill fabric once the fused shell fabric and lining are joined. By sewing a line, connect the two pieces and divide one part for the placement of the charger wire. Twill cloth is used to bind the mobile phone holder's corners and the hole where the charger should go.

12.4 Colour Pencil Storage Bag

People who enjoy creating art utilise colour pencils with pleasure. The best method for changing the human psyche is through artistic sketching. The majority of coloured pencils are sold in thin cardboard packaging, which quickly deteriorates. The cover begins to deteriorate after a few handlings, and the tips of colour pencil boxes that are mishandled or accidentally fall out of the hand are more susceptible to damage.

To prevent this, it was planned to create a colour pencil carrying bag that may be used to transport the coloured pencils while also protecting them if the carton boxes are destroyed. The colour pencils can be organised in order, making it simple to remove the one you desire. Fusible canvas is utilised to give the finished product more stiffness, while pattern-making instruments are employed to create the patterns. This product is made from twill cotton and printed polyester fabric. Figures 14, 15 and 16 show the process of making mobile phone holder.

Four-part patterns are made; the first part is 34 cm long and 23 cm wide, with an allowance of 1 cm for both length and width; the second part is 24 cm long and 14 cm wide, with an allowance of 1 cm for both length and width; the third part is 11 cm long and 14 cm wide, with an allowance of 1 cm for both length and width; the fourth part is 23 cm long and 5.5 cm wide, with an allowance of 1 cm at the top and 0.5 cm for the other three sides.

Fig. 14 Printed khadi and twill fabric of cotton. (Source: Authors)

Fig. 15 Process sequence of the mobile holder while charging. (Source: Authors)

Fig. 16 Mobile holder while charging. (Source: Authors)

The first part pattern should be traced over the cotton twill fabric and interlining with the cut numbers 2 and 1, and the second, third, and fourth part patterns should be traced over the printed polyester fabric with the cut number 1. Only the cut number for the lining should be used for the fourth part.

Twill fabric is cut on the bias with the needed length and a width of 1.5 in to bind the corners of the coloured pencil storage bag. The second, third, and fourth finished fabrics are then connected to the first portion of the fabric after the fourth shell fabric is finished with lining. To store the pencil, the second component that is attached is divided into compartments. The side ribbon for the tie is fastened to the rear of the third section, and the four corners are then covered with twill cloth. Figures 17, 18 and 19 show the process of making a pencil holder.

12.5 Coasters

A coaster, which can be a tiny, shallow plate or a mat, is used to shield hot objects such as tumblers and cups from the tea table or dining room table. It will be crafted from plastic, wooden beads, jute mats, and occasionally fabric. To endure heat, it is typically designed with materials that are simple to clean.

Two separate coaster patterns are made; the first is circular with dimensions of 5 in. and 0.5 in. of allowance, and the second is square with dimensions of 3 in. long

Fig. 17 Printed polyester and twill fabric of polycotton. (Source: Authors)

and wide. Both patterns are traced using cut number 2 over the represented fabric and cut number 1 over the lining and interlining.

Solid cotton fabric with a width of 1.5 in. and the necessary length is cut in bias for the corners of circular coasters and straight for square coasters. The interlining and lining are fused and fastened to the coaster's shell fabric. Finally, bias is used to complete the corners of two separate coasters. Figures 19, 20 and 21 show the process of making the coaster (Fig. 22).

12.6 Spoon and Knife Holder

It is a product that every housewife needs. Every kitchen has more than two knives and five spoons, although homemakers struggle to find them during the hectic early-morning cooking rush. Even if a separate cup is kept for storage, it quickly becomes soiled or disorganised. If washed and kept in the inbox right away, the moisture provides a habitat for microbial growth. Cockroaches occasionally use the boxes as a place to sleep. A fabric pouch will be very helpful for convenient access and storage if it is hung on the wall.

It was intended to prepare a pouch with a spherical shape. For the pouch, denim and cotton fabric were chosen. All instruments for pattern-making and designing are employed, coupled with a canvas.

The spoon and knife holder pattern is made up of two parts: the first part is a half-moon shape with a diameter of 13 cm and a margin of 1 cm, and the second part is a circular shape with a diameter of 26 cm and a margin of 1 cm. The cut number for the interlining is 1, and the cut number for the patterns is 2. These are traced over the denim cloth. Cotton twill fabric is cut in bias with a width of 1.5 in. and the necessary length to bind the spoon and knife holder's corners.

Fig. 18 Process sequence of the coloured pencil storage bag. (Source: Authors)

The interlining and primary fabric of the first and second parts are fused and connected to the lining. The prepared first and second parts are linked together, and the prepared second part's corner is finished with bias twill cloth. The stitching in the second half of the attachment creates compartments for the spoon and knife. Finally, bias twill cloth is used to complete the spoon and knife holder's corner. Figures 23, 24 and 25 show the process of making kitchen tools holder.

Fig. 19 Colour pencil storage bag. (Source: Authors)

Fig. 20 Printed poly cotton and solid cotton fabric. (Source: Authors)

12.7 Notebook Pen Holder

Both working people and schoolchildren can benefit from having a notebook and pen holder. Most folks forget to bring their writing supplies when they stroll around the office or go to other classes. An additional option is to carry the book with a pen holder that is elastic-attachable to the front page. People look for pens and markers while taking exams, auditing, and working long hours. This holder will be practical to carry if it is attached to the diary.

A piece of printed leftover fabric is taken for the preparation of the pen holder. Canvas is planned to use to give stiffness to the fabric and elastic is attached to fix it with the book or diary hard cover page.

Two parts make up the pattern for the notebook pen holder; the first part is 16 cm long, 6 cm wide, plus an allowance of 1 cm, and the second part is 11 cm long, 6 cm wide, plus an allowance of 1 cm. With cut numbers 2 and 1, interline the first part pattern over the solid cotton fabric. With the cut numbers 2 and 1, interline the

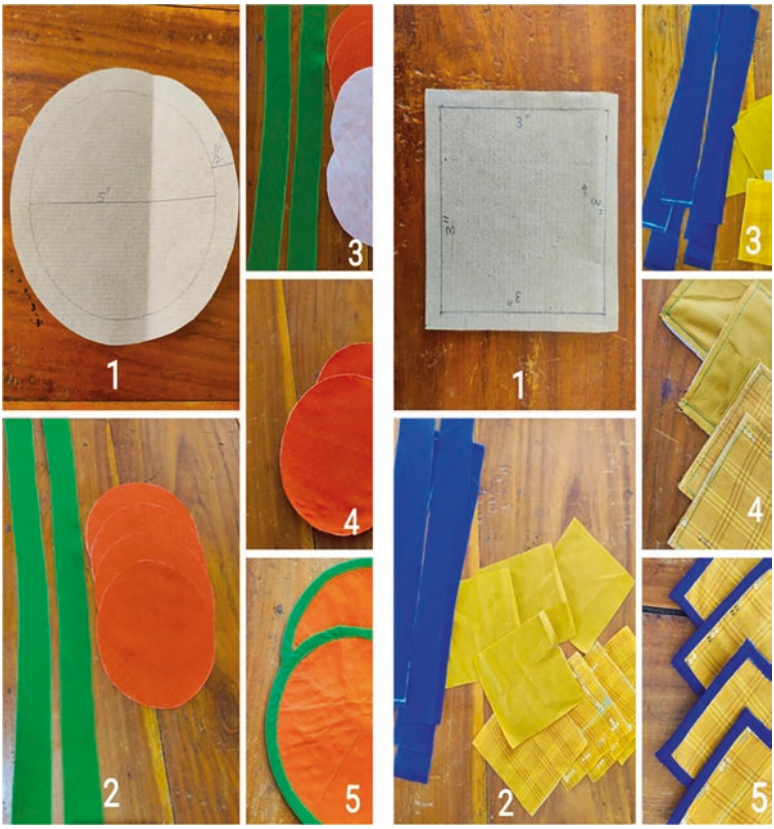

Fig. 21 Process sequence of coasters. (Source: Authors)

second part pattern over the printed cotton fabric. Sew the primary materials and interline them together after fusing them.

Stitch around the corners, leaving some room unstitched to turn inside-out, and arrange the solid cotton fabric first, followed by the elastic and patterned cotton fabric. Turn the stitched portion inside out and use corner stitches to finish the edge. Finally, chambers are made by sewing to accommodate the pens. Figures 26, 27 and 28 show the process of making notebook pen holder.

12.8 Corner Bookmark

For bookworms, a bookmark is a useful tool. Readers who stopped find it to be a useful tool. The majority of bookmarks are in the form of sticks, which are placed in the middle of the book and somewhat obstruct the spine. The use of a corner bookmark might not leave any marks in the book and makes it simple to mark the

Fig. 22 Coasters. (Source: Authors)

Fig. 23 Solid fabrics. (Source: Authors)

pages for later use. It is intended to be made from solid and printed khadi, with a canvas added for stiffness and secure holding.

A corner bookmark pattern is made with dimensions of 3 in. in length and width. The pattern is drawn onto khadi fabric and interlined with cut number 1; it is also drawn onto solid cotton fabric and interlined with cut number 2. The corner bookmark strip is straight-cut with a width of 1.5 in. and the necessary length before being bound.

The khadi fabric is folded in a bias direction and inserted into the paper after the cutter's entire main fabric has been bonded with interlining. The folded khadi cloth is stitched to the fused solid cotton fabric after which they are united. The prepared corner bookmark corners are then bound to complete them. Figures 29, 30 and 31 show the process of making the corner bookmark.

Fig. 24 Spoon and knife holder. (Source: Authors)

13 Post-Consumer Survey

A post-consumer survey is carried out using the quantitative research method, and the information is gathered from primary sources using a questionnaire survey. For the survey, samples are chosen using the convenience sampling method, a non-probability selection technique that takes advantage of the samples' accessibility.

To determine the pricing range for the developed textile items, the survey results from 69 respondents will be used to set the price range. The questionnaire was created using Google Forms and distributed to individual respondents using the social media application WhatsApp.

14 Result and Discussion

Textiles are mostly preferred as clothing to protect our body from heat, cold and light along with it produce lots of waste, which involves textile waste is one of the most polluting wastes in the fashion industry which are very hazardous to our environment.

The wastes are mainly categorised into pre-consumer waste and post-consumer waste. To reduce waste from polluting the environment there are five ways of handling the waste: Disposal (landfill), energy recovery (energy from waste), recycling, reuse, and prevention (reduction).

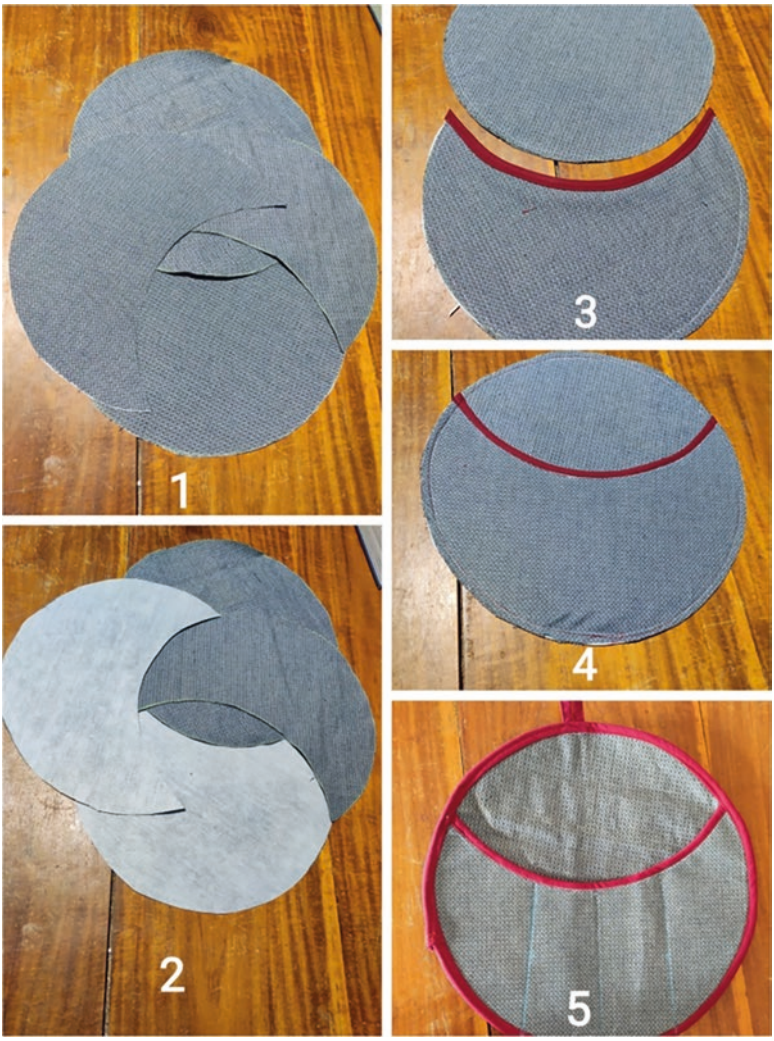

Fig. 25 Process sequence of spoon and knife holder. (Source: Authors)

A pre-consumer survey was conducted to study the consumer's basic familiarity towards environmental pollution by the fashion industry, their preferences towards textile recycled products, what type of textile product they prefer most along with product properties.

In the pre-consumer survey, the most preferred recycled product is household textiles items about 50.9% of people, so I developed upcycle products of household textile items are bell pins and needle holders, headphone holders, mobile holders while charging, colour pencil holders, coasters, spoon and knife holder, notebook

Fig. 26 Printed and solid cotton fabric. (Source: Authors)

Fig. 27 Process sequence of the notebook pen holder. (Source: Authors)

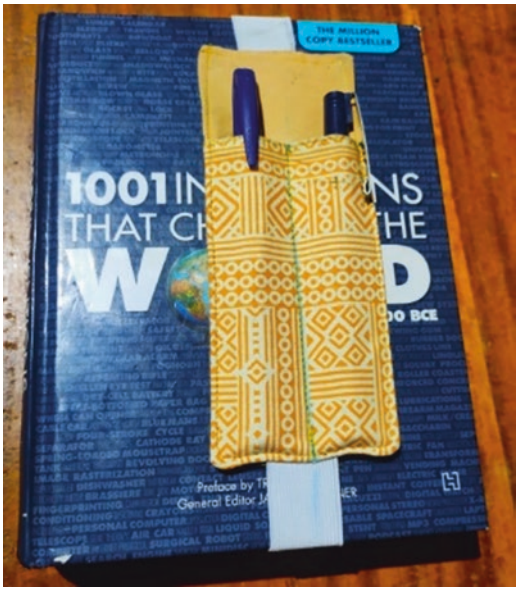

Fig. 28 Notebook pen holder. (Source: Authors)

Fig. 29 Printed khadi and solid cotton fabric. (Source: Authors)

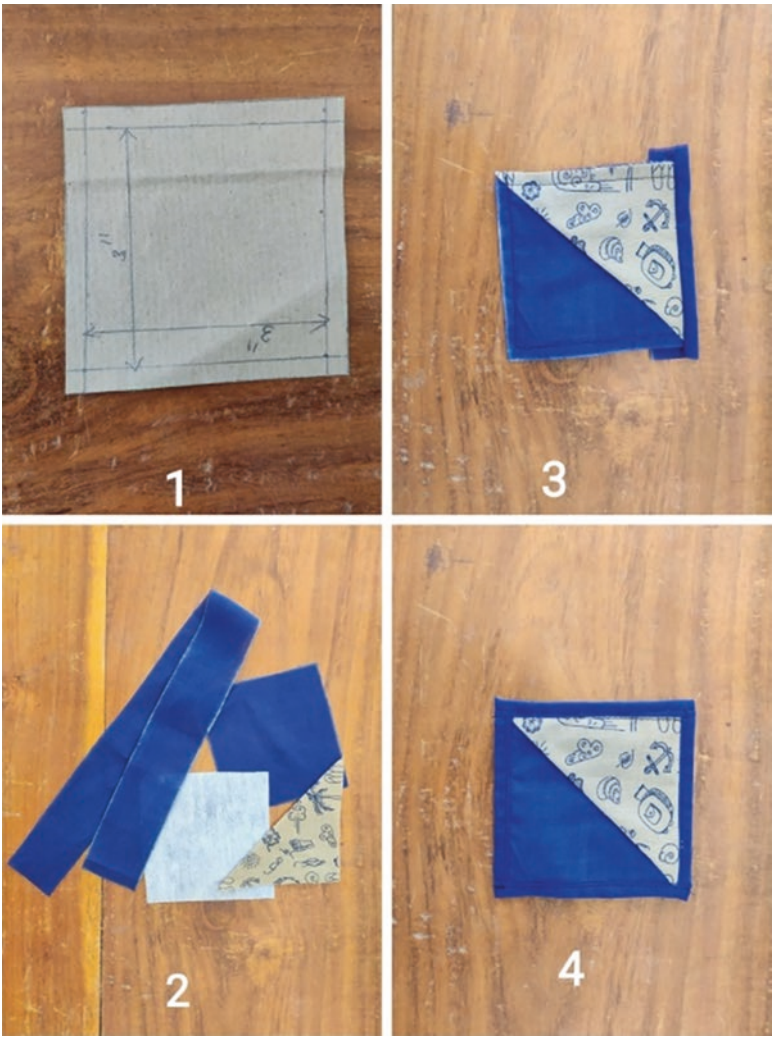

Fig. 30 Process sequence of corner bookmark. (Source: Authors)

Fig. 31 Corner bookmark. (Source: Authors)

pen holder and corner bookmark are developed from the labs of textile & apparel quality evaluation and apparel production in the department of Apparel and Fashion Design in PSG College of Technology, Coimbatore and also the wastes generated after garment stitching in the tailor shop, which comes under pre-consumer waste. The post-consumer survey was also conducted after the development of the product to study consumer preference in product usage, appearance and price range. The responses to the survey are positive.

15 Conclusion

The manufacture of clothing generates greater trash for the textile sector. Even if there are more methods available to recycle textile waste, the quality of the final product actually degrades during the recycling process. To reuse cutting waste as a new product, a trial study was conducted, and consumer satisfaction was also assessed. The consumer supported the novel strategy due to the product's high quality and reasonable price. Guaranteeing the nature's wealth is always healthier to reduce environmental pollution.

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