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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S. S. Muthu (ed.), *Novel Sustainable Alternative Approaches for the Textiles and Fashion Industry*, Sustainable Textiles: Production, Processing, Manufacturing & Chemistry, https://doi.org/10.1007/978-3-031-37060-1_5

Keywords Sustainability · Waste · Fashion Business · Metal wires · Innovation · Textile · Embroidery

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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