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Clothing, its Environmental Impact and Possible Futures

Diploma Thesis

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Declaration

I solemnly declare that I have written the presented thesis *Clothing, its Environmental Impact and Possible Futures* independently and that I have correctly acknowledged all used sources in the list of literature.

In Olomouc 30, April 2020   Signature:………………………………………….

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Abstract

The thesis *Clothing, its Environmental Impact and Possible Futures,* examines the environmental impact that clothing has and what possible role it may play in the future. By exploring the way clothing is produced, used, and discarded, this research helps find possible futures that will reduce its impact on the environment, extend its life of use, and be reused or discarded in a sustainable way. The research in this thesis is focused on using foresight methods such as trends, environmental scanning, and scenarios, to determine possible futures of clothing and its environmental impact.

Key Words

Clothing, Fashion, Environmental Impact, Futures, Foresight Methods, Trends, Environmental Scanning, Scenarios.

Abstrakt

Diplomová práce „Oděvní průmysl, jeho environmentální dopady a možná budoucnost" zkoumá dopady oděvního průmyslu na životní prostředí a jeho možnou roli v budoucnosti. V práci je popsána historie textilního průmyslu, proces výroby a vyřazení oblečení. Cílem tohoto výzkumu je nastínit možné budoucí scénáře, které mají snížit dopad oděvního průmyslu na životní prostředí, prodloužit životnost oděvů, a najít možnosti, jak výrobky znovu použít tak, aby se toto odvětví stalo udržitelným. V diplomové práci jsou k vytvoření scénářů možných budoucností použity foresight metody jako jsou trendy, environmentální skenování a scénáře.

Klíčová slova

Oblečení, móda, dopady na životní prostředí, budoucnost, foresight, trendy, environmentální skenování, scénáře.

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Introduction

Clothing, along with food and shelter, is something humans use and need to be able to strive and thrive in daily life (Sabit, 2001). From the blazing sun in the equatorial zones, clothing protects delicate skin from being burned. Clothing protects from the whipping winds in a sand storm and keeps us warm when exposed to the elements. Clothing comes in all colors, textures, styles, but it all has one common element to protect the user. Simply put clothing is a basic human need (Maslow, 1943).

During the last century enormous changes have emerged in the world's textile and apparel industry, because of improved technology, equipment, machinery, transportation, and collaborative trade agreements between countries. Clothing sales play a significant role in the global economy. In 2016 retail sales in the industry were 1323.1 billion dollars and estimated to be 1659.5 billion dollars in 2021 (Statista, 2018). Both clothing manufacturers and retailers are dependent on the world's consumers. The apparel business wraps around the world, but is dependent on satisfied customers for the products produced and retailed. One of the outcomes is the enormous amount of textile waste by both the manufacturers and the consumers (Kunz et. al. 2016).

The textile industry is responsible for the use of large quantities of water, as well as the disposal of toxic metals in the soil, the air, and the water (Neto et. al, 2019). The fashion industry is a major contributor to global water pollution and consumption (Nayak et al., 2019). Recently numerous books, such as *Fashionopolis* (Thomas, 2019), *Inconspicuous Consumption* (Schlossberg, 2019), and *The Conscious Closet* (Cline, 2019), have been published enlightening the world to the environmental impact of fast fashion and bringing awareness into the mainstream world view.

The term fashion refers to the kinds of clothing which have social validity, clothing that is accepted as fashionable, or "in" by the society or by specific groups of society. Fashionable clothing has an increased value because they carry supplementary aesthetics and usefulness (Lockchek, 2009). Fashionable clothing can be labeled as beautiful, functional and trendy, it has

an added value to the public in order to make someone feel valued. The terms fashion, apparel, and clothing can all be interchangeable in the context of this work.

The first segment of this thesis looks at the history of clothing and the technological changes that have moved it forward in time. The history of clothing is important to understand, because it gives a picture of what changes have occurred. By looking at the technological changes that were made to improve and advance the production of clothing. This perspective gives a wide view of the challenges and improvements made, as well as the stepping stones that brought us to where we are today. The industrial revolution technologies used in clothing manufacturing shaped and formed the modern economy and current lifestyles. The past challenges are connected to the challenges faced today and by looking at the past it can help with the assessment of the future.

The environmental impact of clothing is broad and complex. The topics within the environmental impact of clothing could stretch on with years of study. Focusing on a few of the categories gives a more indepth look at specific topics. The section titled *Current Environmental Impact of Clothing* has been divided into three separate sub-chapters to facilitate the ability to go into depth on each subject. Each topic has direct connections to environmental concerns. Starting with microplastics and laundering, clothing disposal, and ending with sustainable fashion. These focus topics were chosen because they are all topics which the consumer has some portion of control over. The manufacturing process which is largely invisible to the consumer, will be mentioned as it plays a large role in the topic, but is not the primary focus.

The current assessment of clothing and its environmental impact, is crucial in creating a snapshot of today and looking beyond into the future. Looking closely at ways clothing is bought, used, and discarded. Also looking for potential technologies that can help to reduce the environmental impact of clothing during the manufacturing process, the laundering processes as well as ways to recycle clothing are considered.

Figuring out and implementing sustainable solutions in the textile and fashion industry has a long road ahead due to the long supply chain. One of the most important influences is the consumer and their practices at home. Consumer attitudes toward sustainable clothing, up-cycling methods, information share ability and the degree of understanding in the clothing

fiber production process. These attitudes determine purchases of sustainable fashion product for families, washing and energy consumption, recycling and used article trade as a way of life for sustainable clothing (Shim et al., 2018). Understanding of what is happening right now will lead to a better understanding of the future.

Methodology

Clothing is found throughout human history and now more than ever is leaving a larger footprint that it ever has before. The aim of this work is to combine history, trends, and environmental scanning to complete potential scenarios for the future of clothing and its environmental impact in the future. By exploring the way clothing is produced, used, and discarded, this research helps find possible futures that will reduce clothings impact on the environment, extend its life of use, and to be reused or discarded in a sustainable way. The geography of the forecast is based on the western consumer and their use and disposal habits, which had an effect around the globe.

The time horizon for this future study is 2030. Looking ten years ahead is considered a medium range forecast where elements of the expected future, such as constants or trends, can be assumed to continue over this time frame (Bishop and Hines, 2012). When looking at the environmental impacts of clothing, a ten year look into the future is adequate, because emerging technologies and current trend trajectories are within range. To stretch beyond a 10 year horizon time frame would be considered a long term forecast, more unknown variables come into play. For the focus of this study, to look at the future of clothing, ten years is appropriate.

Primarily focused on social change theories, noticing how society works and shifts the future. Culture Theory, which assumes a society is based on its culture more than on its material environment or its technologies that manipulate it. Culture Theory argues that technology is a part of culture and that different cultures have different attitudes toward technology. Those attitudes can allow technology to be the main driver of change, or just a sideline activity. Ideas are the key components that give culture its ability to drive change. Social changes occur in the

micro world involving human consciousness and thus leading to technological innovations (Bishop and Hines, 2012). Culture creates and adopts technological changes which in turn lead to more changes. That in mind many of the defining changes are seen as technological changes and many of those changes are highlighted. This theory is used as a focal point to show how the past was developed, detect drivers of change, and how the future may look.

The objective of using futures methodology is to methodically explore, create, and test both possible and desirable futures to improve decision making in order to shape a desired future. Nature, social and political dynamics, scientific discovery, and technological innovation all generously influence the future. However, the role people play has become much larger as our capacity has evolved, human choices increasingly shape the future. While the future is not controlled by society, societal goals can be accomplished influencing how the future looks. Futures methods highlight anticipatory consciousness, with foresight, which improves ability to act faster or earlier, helping to shape the desired future. Future methods help create a picture of what we want, what is possible and what may be. Of course the desired futures are not all going to turn out just as planned. Futures research is not just focused on forecasting accuracy, it is more useful in planning and opening minds to consider new possibilities and changes that may be approaching, so we may be anticipating the changes and will have the opportunity to adapt in a relevant way (Glenn and Gordon, 2009). The future methods used are those outlined in Bishop and Hines (2012) *Teaching About the Future*, in order to determine possible futures of clothing and its environmental impact. More in depth information on specific methods applied, was appropriated from *Future Research Methodology* (Glenn and Gordon, 2009).

Literature research is used heavily within this body of this thesis. In order to frame an accurate understanding of the subject matter, many academic articles were found on the study topic and reviewed relating to this thesis. Creating a strong knowledge of the history of the topic is an important step in understanding what may materialize in the future. Considering that there is no actual first-hand information about the future (Bishop and Hines, 2012), research is essentially the backbone to all future information. The base of research here is secondary research. According to Bishop and Hines (2012, page 173) "Secondary research generates ideas and evidence, with key emphasis on the ability to analyze and interpret what is found." On this topic there is a vast amount of academic articles, books, newspaper articles, and other information referring to the topic of clothing and its environmental impact. While primary

research could be beneficial it is not essential or included, due to the plethora of information available on this topic and time constraints. Finding the center of the domain helps build a framework on which the foundation of the research will stand (Clark, 2009).

Focusing on history highlights its past technological changes that have propelled advancements in creating the future. These changes give a glance of what the past had to overcome and may lead to what the future may look like. Challenges, obstacles, and improvements related to the past can be seen as ways to improve the future. Using future methods is a way to help identify what you do not know, but what you need to know, in order to make well-informed decisions (Glenn and Gordon, 2009). The past leads to the present which will develop into the future.

Examining the current era is perhaps one of the most important areas to research in future studies. Study and understanding of the current time is important, because of its ongoing sway and influence projecting into the future. This element helps develop an understanding of today's world. Considering the process of how this era came to be is important, as well as understanding why and how it happened. Assembling a snapshot of the current era emerges directly from the history of the domain. Connecting the dots that form the past and the present. The history has led to the current era recognizing the reasons, process and development of this time period opens the doors to focusing on the future. Political, technological, economic, environmental, and society have all influenced and been altered by this age. The current era has an enormous influence on what the future will look like, also it has led us to the current time period (Clark, 2009). But what is going to be next?

In order to focus on future possibilities the current emerging trends must be identified. Trends are the one of the three basic drivers of change along with events and issues (Bishop and Hines, 2012). These trends are important factors to consider while looking at the possible future of how society, technology, government, environment, and economic factors that come into play will mature and create the new era. This framework for making sure all these sectors are covered is by using STEEP. The STEEP acronym stands for Social, Technological, Economic, Environmental and Political aspects of society (Bishop and Hines, 2012). All of the STEEP areas are covered in this body of work. Trends set the mood and projections of what is to come. Focusing on the trends that have emerged during the past year (2019) to present.

These trends will then be used in part to help form the future scenarios. While some of these trends are specific to the time being others will transform the way the industry is evolving. While keeping in mind that not all trends translate into revolutionary changes some will simply fade a way into history. Current trends are the propellant to the future, ideas that evolve into popular culture, changing the way people do and think about things. Trends are found within a variety of sources, many of them being found within the current media. Identifying trends goes hand in hand with the process of environmental scanning.

Environmental scanning is a method used and is a critical part of futures research. Scanning the horizon is Environmental scanning is looking for developments on the horizon that could potentially change the future. These new developments can challenge past assumptions or provide a new perspective about future threats or opportunities. Environmental scanning systems provide early warning about important changes and detect "weak signals" that indicate plans should be amended. The objective of scanning is to find early indications of possibly important future developments in order to gain as much lead time as possible, to prepare for the changes and to be in a position to influence the change (Glenn and Gordon, 2009) Another important part of scanning is keeping an eye out for wild cards. Scanning also includes wildcards that may come in to play, unknowns that will drastically shape the future. Wild cards are low-probability, high-impact events that have significant consequences (Peterson, 1997). Wild cards are often unpredictable and unseen events with foresight these elements of surprise can be prepared for or at least considered in elements, so they do not come as total shock. Factors influencing the future include looking closely at each of the areas of STEEP. For this portion of research additional sources are relied upon including: current events, mass media, books both fiction and nonfiction, online sources, blogs, podcasts, or anything else that looks like a viable source that may become valuable in the meantime.

The final method used is scenario planning. Scenario planning is one of the most popular qualitative forecasting methods used to up to date. A scenario is a story with plausible cause and effect links that connect a future condition with the present, while illustrating key decisions, events, and consequences throughout the narrative (Glenn and TFGI, 2009). Scenarios are not a forecast of the future, but rather they are possibilities of what the future may look like. Scenarios present the consequences of decisions based on future possibilities and what those occurrences may look like (Novacek, 2011). Developed by using the information

gathered in the history, current era, trends, and environmental scanning three scenarios are presented.

Along with the previously mentioned future methods, creative thinking, and creativity are combined in generating the scenarios. These scenarios propose a range of possible futures. Scenarios are developed in a way so that one can clearly see and comprehend the problems, challenges, and opportunities that such an environment would present, describing events and trends as they could evolve. The purpose of creating scenarios is a way to systematically explore, create, and test consistent alternative future environments that encompass the broad set of future operating conditions that the user might plausibly face (Glenn and TFGI, 2009). The snapshot each scenario provides into the time and condition of 2030 provides important variables. They also describe a future history, one that has evolved from the current conditions to one of several futures. The goal of the constructed scenarios is to: catalog what is unknown to what out to be know, understand the significance of uncertainties, illustrate what is possible and what is not possible, identify what strategies might work across a broad range of possible scenarios, dichotomize strategies between robust and contingent elements, make the future more real for decision makers to force new thinking and decisions, and learn how to be prepared for future risks and uncover new opportunities (Glenn and TFGI, 2009).

Three descriptive scenarios have been formulated each including different drivers of change, trends, events, and issues paired with information gathered with the environmental scanning process and current trends. Three scenarios are formed, probable, possible, and profered. The stories formulated as scenarios are relatively short one to two pages as suggested by Bishop and Hines (2012), in order to keep them memorable. Creating the three scenarios with different driving forces enable to diversify possibilities of what the future can look like. Creativity and creative thinking are implemented to create a scenario that is interesting, persuasive and a future possibility.

1. History of Clothing and Technological Changes

To be able to fully understand the imprint clothing makes on the environment, it is important to understand its origins and history. Cultural changes and innovations have led to

technological changes. These changes have evolved the way clothing is made, worn, and discarded. From the Pleistocene period, Neanderthals were the first known humans known to make and wear clothing. From this era there is no direct tangible evidence, but clothing related items have been discovered such as buttons, eye needles, and a few artistic depictions corresponding to the use of clothing (Gilligan, 2007). The needle and buttons which are still used today can be considered the first technological advancements made when it comes to clothing. These early indications of clothing and other advancements helped propel clothing forward.

Neanderthals learned to make tools from stone, such as axes and spears. With these technological changes they were able to effectively hunt hairy mammoths, bears, deer musk, oxen and others. Consequently, the Neanderthals discovered how to use the thick furs and hides from these animals to protect themselves from the elements. Anthropologists estimate that between 100,000 and 500,000 years ago the first clothing was worn (Das, 2019). The first clothing was made from natural elements such as animal skins, furs, grasses, leaves, bones and shells. These natural fibers were found in nature and used with little alteration were presumed to go back to nature in a state similar than it would have otherwise. The first clothing is thought to have been worn draped or simply tied (Das, 2019).

European early modern humans made advances in clothing around forty thousand years ago. Simple needles made out of animal bone provides evidence that leather was sewn from at least 30,000 years ago (Das, 2019). Sharp awls and other pointed tools were used to punch holes in animal skin, which was then sewn together with hide string. These technological advancements improved the fit of clothing providing a way for more fitted garments and better protection from the elements. At this time the early modern humans had not yet discovered how to tan hides, so the leather would have been stiff, but repeated wearings would have softened the leather and become more comfortable. Simple close fitting garments such as paints, shirts, shawls, hoods, and long boots were developed in these early stages.

Clothing stayed more or less the same over many thousands of years, made with animal skins and natural fibers. One of the oldest preserved examples of clothing, dating back more than 5,000 years, was discovered on the ice mummy nicknamed Otzi. Discovered in 1991, in Austria's Tyrolean Alps, in the melting ice of the Similaun Glacier, Otzi remains intact with his

belongings. On the remains of his body were fur and leather garments and shoes. The garment found was highly refined and very well preserved, made mainly from goats and cattle, but also his cap was made of bearskin. "The care with which various animal skins of contrasting colors were selected and matched and the elaboration and coordination of the attire point to a complex encoding of role and personal identity" (Vidale et. al., 2016). This example draws attention to the cultural value and status of clothing even many thousands of years ago.

1.1 Spinning to the Loom

Flax is believed to be the first fiber used for making clothing. Flax fibers were discovered in a Dzudzuana cave in the Republic of Georgia dating over 34,000 years old. The use of flax fibers was of great importance to the hunter gatherer society. The flax fibres were used to sew hides together to make clothing and shoes, some of the fiber found were twisted to make string or rope others fibers found had been dyed (Harvard University, 2009).

Flax was not the only fiber used in making usable string, thread, or rope, other fibers had been used as well. Transfiguring flax, wool, cotton, silk, hemp, or ramie into thread required skills and tools. The earliest tools were spindles and distaffs, millions of which have been excavated from the world's oldest archaeological sites. Threads were formed that could be used to create rope and nets, and then when woven together on looms, felted or knitted formed into textiles. These great technological changes allowed for greater efficiency in everyday life (St Clair, 2019).

One of the challenges faced was producing fiber, this was achieved using technical innovations that many different cultures adopted. The process of fiber making begins with spinning. Spinning is the method of turning fibers into threads and has the same principle in all methods: pull fibers, twist them, and wind up thread. This process in the beginning was done by hand rolling the thread on the thigh, then the spindle came along making the process more productive by using a drop spindle. In the middle ages a new invention took hold and the spinning wheel became the preferred method for spinning fibers. The foot-powered spinning

wheel allowed a person to spin four times faster than with a drop spindle, making production more efficient and demand for thread to be met faster (Barber, 1994).

Early weaving has been found throughout the world, however it has no known origin source due to various cultures and civilizations who incorporated weaving. Before the industrial revolution weaving depended almost entirely on the handicraft skill of the weaver. The process was cumbersome and complicated and entailed a great amount of labour and patience (Barlow, 1878). In prehistoric times it is believed that cloth making consumed more working hours than making pottery and food production combined. For example, in ancient Egypt, linen, the most common textile used for making clothing, involved many people, farming and making it into cloth. The results of this hard work can still be seen today on the mummified bodies of the ancient Egyptians (St Clair, 2019).

The earliest written record of weaving can be found in the Old Testament where reference can be found referring to the loom and its products "of curtains of fine twined linen, and blue and purple and scarlet, with cherubims of cunning work" (Bible, Exodus 26:1), and in the book of Job (Bible, Job 7:6) "My days are swifter than a weaver's shuttle, and are spent without hope" are just a few examples of how the process of cloth making was integrated into culture. Weaving consists of interlacing two sets of thread that have been made at right angles into each other. Thread can be very floppy and so a frame to hold one set of threads was created this is known as a loom. (Barber, 1994).

The earliest looms required the weight of a human body, known as a band loom, the weaver was required to tie the thread to oneself and a solid non-moving object such as a tree, post, or the weavers big toe to hold the tension of the threads (Barber, 1994). Later models of looms were more complex horizontal or vertical models made of wood frames and weighed down with large beds of stone or clay (St Clair, 2019). The early loom required a significant amount of time and labor to be invested into making a piece of cloth. Over time the loom has made significant advancements.

The craft of spinning, weaving and sewing was largely considered a task for women, most hours of a woman's day would have been spent on textile related activities. One reason for this is because women could work on textile production and still attend to children. Occasionally

men would spend time on textile related activities such as, in Europe men were typically the ones to shear the sheep, plant the harvest of flax and market the extra textiles for cash income (Barber, 1994). Textile related activities did not only provide clothing for people it also provided a way to produce income. The production of processed fibers materials were traded by their makers forming an intricate network that spread throughout the world. Trading brought the concept of credit and bookkeeping. Making cloth became a way to make money (St Clair, 2019).

With the increased demand for fabric in the market, innovation became urgent. In 1760 the *Journal for the Society for the Encouragement of Arts, Manufactures, and Commerce* put out a call with a reward for "a machine for spinning six threds of wool, cotton, flax, or silk, at one time, and that will require but one person to work and attend it" (St Clair, 2019). The technologies that followed forever changed the way the textile industry works and provided the means to launch into the current era.

1.2 Industrial Revolution

Textile manufacturing was a key driver during the Industrial revolution. Technological innovations provided a huge push in the textile industry contributing in terms of employment, value of output, and capital invested. One of the first major applications of the new steam engine was used to implement the mechanization of making cloth (Barber, 1994). Over the next century the production of fabric soared with inventions such as the spinning jenny, the water frame, the power loom, and the cotton gin (St Clair, 2019). With each new invention innovations were made and improvements reflect similarities of the models used today.

The spinning jenny was invented in 1764 by James Hargeaves. The spinning jenny reduced the amount of work, because the worker could produce 8 spools of thread at once instead of one and later on as many as 120 (Baines, 1835). The tread from the spinning jenny helped start the factory system of cotton manufacturing. Although this invention was a massive improvement on what was used before, the thread produced from the spinning jenny composed a coarse thread that was not very strong. Building upon the spinning jenny, the water frame helped solve this problem.

The water frame was a spinning frame that was powered by a water wheel. The water frame could produce 96 threads at a time, it was easier, faster to use, and produced thread that was much stronger than the thread produced by the spinning jenny. The water frame was patented by Richard Arkwright in 1769 (Simkin, 1997). Factory spinning was soon followed by power weaving around 1785 and took decades to perfect. Edmund Cartwright patented the power loom which used water power to speed up the weaving process. This loom is the predisour to the modern loom which we use today (Allen, 2017).

Other inventions keep coming leading to more efficient textiles. In 1801, the Jacquard Loom was invented by Joseph Marie Jacquard. This loom made it possible to mass produce textiles with complex woven patterns, something that before this invention required a great amount of time, skill, and expertise to assemble. The Jacquard Loom was programmed or controlled by pieces of cardboard marked with a series of holes that determined the pattern on the fabric. These hole punch cards did not just change the way fabric was produced, but they later revolutionized computing (St Clair, 2019).

In the 1930's the appearance of the lockstitch sewing machine made ready made garments output sped up but demand was still limited due to the fact many people purchased fabric and made clothing at home. This changed with the Civil War, with both sides needing uniforms quickly, these uniforms were made to a standard sizes, meaning they were ready-to-wear. As a result of the lockstitch sewing machine, factories were quickly set up and the uniforms were assembled, quickly to meet the demand. The response from the troops was welcoming with a demand for ready-to-wear clothing after the war. Manufacturers started by producing men's wear followed by women's wear in masses, creating the apparel industry in the United States (Thomas, 2019).

The industrial revolution moved basic textile work out of the home and into large factories. With these cultural changes women and children were shifted to the factory to work. Minding these huge, dangerous, unforgiving machines in the mill caused overwhelming social problems (Barber, 1994). Since this time the fashion industry has been a ruthless business that has exploited humans and the earth to gain massive profits. Slavery and child labor have always been a part of the supply chain and is still a problem today (Rivoli, 2009).

These new technological innovations globalized textile and clothing manufacturing. During the Industrial revolution England and New York became the leaders in the process and production of clothing. Clothing was made on a scale never seen before while sourcing supplies from all over the world, and final products shipped around the world (Ross, 2008).

In the United States in 1899, the National Consumers League called for the end of sweatshops and unethical labor practices. Florence Kelley, general secretary of the National Consumers League called for shoppers to think ethically about their purchases, stating "We can have cheap underwear righteously made and clean; or we can have cheap underwear degradingly made and unclean. Henceforth we are responsible for our choice." (Thomas, 2019). Although the League did make an impact and had many stores carrying their "white label," meaning the clothing had been certified that the manufacturer respected all state employment and safety laws as well as the League's standards, many factories still violated health codes. One of the most tragic disasters in the garment industry at the time was the Triangle Shirtwaist Factory fire in 1911. A fire broke out in the factory and with the doors locked workers had nowhere to go all in all 146 of the employees died, 123 of them women aged 14-23 (Osha, 2012). This was the largest workplace disaster in New York City up until 11th of September 2001.

In this long and complex history one important factor when looking at the environmental impact of clothing is dye. To color the fabric before 1856 natural dyes were used. These dyes were expensive and labour intensive to extract and use, such as indigo, Tyrian purple, and others. Hand in hand with the Industrial Revolution in more chemicals were being produced as by products of industrial processes and some of these made exciting pigments and dyes. In 1856, while trying to find a cure for malaria, William Perkins at the age of 18, serendipitously found the first synthetic dye, Mauveine. This accident forever changed the process in which cloth is dyed in large quantities. This intense purple color is among one of the first chemical dyes to be mass produced (St Clair, 2017).

In 1938, DuPont announced the "first man-made organic textile fiber," nylon. As DuPont put it, nylon was one of the most important developments in all of industrial research. The company had engendered it to be as strong as steel, but as fine as the threads in a spiders

web. Nylon became a staple in women's wear replacing silk stockings. Earning DuPont more than $4 billion dollars between 1940 and 1967. With the onset of World War ll, the production shifted from women's stockings to military supplies such as parachutes. After World War ll, the synthetic-fiber market expanded as Americans experienced record economic growth. Synthetic fabric clothing was promoted as high performance, inexpensive, comfortable and easy-to-care-for (Meikle, 1997). These new synthetic fabrics are a form of plastic and repercussions would not be noticed for a long period of time. The current industry of clothing would look nothing like it looks today without these cultural and technological changes that have evolved and shaped the current era.

1.3 Fast Fashion Era

Beginning in the late 1950's, retail buying offices in developing countries began forming international business relationships. Their goal was to supply US and European apparel retailers with finished garments that were different and at a lower cost than what was currently being offered by domestic apparel firms. International buying offices grew in number and popularity until the late 1980s when merchandisers and designers got involved in product development for private label lines. The race began for development of supply chains that included the lowest cost labor with the highest efficiency to make garments anywhere in the world. This led to the development of the standard merchandise identification system, essential for processing goods that are transported from one country to another (Kunz, et al., 2016).

In the 1970's the United States produced at least 70 percent of the clothing Americans purchased. Because of the New Deal, most of the twentieth century brands and manufacturers were expected and held to strict national labor laws. Beginning in the 1980's the apparel industry began to shift, producing huge amounts of trendy clothing, at inexpensive prices, as fast as possible, and retailed at chain stores. To make all of this possible the cheapest labor was used in some of the world's poorest countries. Offshoring caught on all across the industry, at this time globalization was accelerating (Thomas, 2019). Changes in the way clothing was produced created a new reality for consumers. The birth of the fast fashion era was gradual, due to policies and trade agreements that emerged.

The United States textile and apparel industry peaked in 1973 with about 2.4 million employees. By 1996 the number of U.S. workers had fallen to 1.5 million and by 2012 there were only 383,00 workers left (Minchin, 2013). The demise of the industry in the United States had somewhat to do with companies seeking cheaper labor overseas, but the collapse of the industry in the US also coincided with the signing and expiration of several trade agreements. In effect from 1974 until 2005, the Multifiber Agreement (MFA), imposed quotas on textile exports from developing countries to protect the industries in the United States and the European Union. The MFA came under criticism for creating barriers to trade for developing countries, it also did not have the intended effect of protecting apparel and textile jobs in the industrialized countries. When the Multifiber Agreement was phased out in 2005, the market moved more toward free trade. The MFA artificially spread the market around the world. When it was lifted China and Bangladesh were able to take control of more global trade (Newman, 2017). Other trade agreements also had effects on the apparel industry.

In 1994, the United States signed the North American Free Trade Agreement (NAFTA). NAFTA ultimately moved production factories to maquiladoras in Mexico. Within the first six years of NAFTA, Mexico's apparel exports to the US increased sixfold. By 2000, Mexico was the biggest garment exporter to the United States. Not long after exports from China rose, pushing Mexico out of its position (Minchin, 2013). Today there are roughly 14 trade agreements in the US concerning the apparel industry. Many of these agreements have rules of origin that do not reflect the global economy. For example, if companies have to make clothing that comes from yarn from a free trade area, they may save 10 percent on tariffs, but they will end up spending much more on fabric that is much cheaper coming from parts of Asia (Lu, 2017).

Due to the many trade agreements the shift of the supply chain became more complicated and hard to follow. Products are not simply shipped from one country to another anymore. The globalized supply chain is complex and intricate. The supply chain may look something like this: cotton is grown and then shipped from the United States to Japan. In Japan the cotton is turned into fiber, which is then shipped to China. In China the fiber is turned into yarn and fabric, which is then shipped to Vietnam. While in Vietnam the fabric is made into apparel which is shipped back to the United States for sale (Newman, 2017).

The results of globalizing the clothing industry was dramatic. First hit was labor in developed economies. Over the last thirty years fashion has grown from a $500 billion trade, which was primarily domestically produced, to a $2.4 trillion dollars a year global industry (Thomas, 2019). The speed of the market rocked the developed economies. In 1991, 54.2 percent of all clothing purchased in the United States were American made and by 2012 it was down to just 2.5 percent. Offshoring created massive trade deficits and substantial job losses for developed nations. During the time period of 1990 and 2012 the US textile and garment industry lost 1.2 million jobs, this was equivalent to three fourths of the sector's labor force. Similarly the United Kingdom in the 1980s had one million people employed in the textile industry and by 2019 only one hundred thousand. The majority of these jobs shifted to Latin America and Asia. Globally during this same time frame the amount of textile and apparel manufacturing jobs nearly doubled from 34.2 million to 57.8 million (Thomas, 2019).

Historically, clothing was easily distinguished from low-end, mass market, and high-end items clearly separated by price brand and quality (Anguelov, 2016). Around the year 1998 the word 'fashion' changed, from being associated with designers to now meaning clothing (Ross, 2016). One way fast fashion can be defined is as, low-cost clothing collections which are based on current high-cost luxury fashion trends (Fletcher, 2008). Fast fashion is very popular because there is a short time gap between production and distribution, and also provides fashionable, relatively inexpensive clothing, although the quality of the clothing is not considered to be high quality (Gabrielli, et. al., 2013). Fast fashion is considered to be a response to postmodern consumers' needs as a way to create and express self expression. The consumer sees fast fashion products as offering freedom, fun, pleasure as a creative way to express various forms of identity, even though fast fashion is of lower quality, global and homogenous (Gabrielli, et. al. 2013).

The fast fashion phenomenon has revolutionized the clothing industry over the past decades. Changing consumer attitudes to apparel consumption, linked with low-cost production and sourcing of materials from overseas industrial markets has led to a culture of impulse buying in the fashion industry. New styles of clothing are available to the average consumer every week (Turker and Altuntas, 2014). The fast fashion model in major retailers has new clothing designs introduced to stores every three to five weeks (Hu et al., 2014). Shoppers have responded to the low price clothing by buying a greater variety and more items of clothing.

Developing economies have also seen a rise in clothing sales, Brazil, China, India, Mexico, and Russia had apparel sales that grew eight times faster than Canada, Germany, the United Kingdom and the United States. The reason for this is due to a rise of the middle class, in these emerging economies making sales robust around the world (Remy et al., 2016). With the boom of fast fashion, comes problems that need to be addressed.

Over the past 15 years the world population has grown by 21.6 percent and global exports have increased by 123.4 percent (Lu, 2017). The number of garments annually had doubled since the year 2000 and exceeded 100 billion the first time in 2014, that is the equivalent of 14 items made for every person on Earth (Remy et al., 2016). One of the ways fast fashion works is by producers building up mass production systems by outsourcing makes them competitive because of lower price, customers in turn have a decreased financial burden and become more intemperate in spending. Repetition of intemperate production and consumption has led to various problems, including resource waste and clothing waste and has become a social issue (Shim et al., 2018). The competition is fierce in the apparel sector and there are so many supplies oversupply has become a problem. Companies have to compete on price and by doing so are always looking for the cheapest labor. "The oversupply problem in the age of fast fashion is getting worse, not better" (Newman, 2017).

According to Thomas (2019) the fallout has been great in terms of the fast fashion takeover. First, the labor markets shift due to offshoring. Second to be hard hit by the development of fast fashion has been human rights in developing nations. Currently the fashion industry employs one out of every six people in the world, making it the most labor-intensive industry globally, even more than the agriculture and defence sectors. Fewer than two percent of people working in the fashion industry earn a living wage (Thomas, 2019). The third impact of fast fashion has been the Earth with resources and environmental impact. With the fast fashion era that distinction has all but disappeared. The fast fashion clothing industry has become a trend of today's society which is preoccupied with trending fashion rather than quality and physical life of the product.

2. Current Environmental Impact of Clothing

The textile industry from fiber to garment production is one of the most polluting and waste generating sectors in the world, causing vast amounts of environmental problems (Utebay et. al. 2019). Among the top pollutants are carbon emissions, water pollution, and users of toxic chemicals (Cline, 2019). There are many steps along the supply chain to get raw material turned into fabric, sewn into clothing, and distributed to the population. However, this not the end of the environmental impact clothing has, laundering, as well as disposal have consequences for the environment. The consumer plays a significant role in the impact clothing has.

The world fiber consumption is continuing to increase because of population, quality of life and the fast-cheep-fashion effects. Significant amounts of textile waste is produced and a majority of textile wastes are disposed of (Utebay et. al. 2019). The fashion industry is responsible for nearly 20 percent of all industrial water pollution (Thomas, 2019). In 2015 the fashion industry consumed 79 billion cubic meters of water (Little, 2018). The clothing industry among the world largest carbon emitters, as much as 8 percent of carbon emissions are caused by fashion (Cline, 2019). To put this into perspective to produce 1 kilogram of cloth generates 23 kilograms of greenhouse gasses (Thomas, 2019).

The demand for textile products is steadily increasing, this trend is likely to continue due to population growth and economic development (Oerlikon, 2010). On the other hand the textile industry is facing numerous environmental and resource challenges. Sixty-three percent of textile fibers are diverted from petrochemicals (Lenzing, 2017). Synthetic fibers production and fate give rise to considerable carbon dioxide emissions (Shen et al., 2010). The remaining 37 percent is dominated by cotton (at 24 percent) which is a thirsty water consuming plant, the cotton plant is associated with water depletion. The Aral Sea is the most infamous example of cotton contributing to water depletion and toxic pollution due to the extreme use of pesticides (Micklin, 2007). The later stages of the textile production process provide an even larger scale of environmental impacts, then the beginning stages (Roos et al. 2015a). Wet treatment processes, which consist of dyeing, finishing, printing, ect., are major sources of toxic emissions

(Roos et al., 2015b). Spinning to process yarns and weaving/knitting of fabrics most often rely on fossil energy use, creating carbon dioxide emissions and other particulates that pollute the environment (Roos et al., 2015a). Greenhouse emissions, water use, toxic chemicals, and waste are the main environmental issues facing the textile industry (Allwood et al., 2006). It is estimated by Sandin et al. (2015) that for several environmental impact categories, the impact per garment use in a western country must reduce by 30 to 100 percent by 2050 if the industry is to be considered sustainable with regards to the planetary limits outlined by Steffen et al. (2015).

Polyester is the most widely used manufactured fiber, it is made of petroleum. With the rise of production in the fashion industry, the demand for man-made fibers, especially polyester has nearly doubled in the last 15 years. The manufacturing of polyester and other synthetic fabrics is an energy intensive process requiring a large amount of crude oil. The process releases emissions including volatile organic compounds, particulate matter, and acid gasses such as hydrogen chloride, all of these can cause or aggravate respiratory disease. By products such as volatile monomers, solvents and others of polyester production are emitted in waste water at the polyester manufacturing plants. The Environmental Protection Agency (EPA), under the Resource Conservation and Recovery Act, considers many textile facilities to be hazardous waste generators (Claudio 2007).

Man-made fabrics are not the only contributor to environmental health and safety. While polyester is the most consumed fiber, followed by cotton throughout the world. The share of cotton in total fiber consumption in 2017 was reported to be 24.1 percent (Lenzing, 2017). Cotton is one of the most popular and versatile fibers used in production of clothing manufacturing, it also carries a significant environmental footprint. Cotton does have the advantages of being a natural fiber, but the production of cotton production carries severe environmental impacts in the forms of water consumption, land occupation, emissions and the use of pesticides. Pesticides applied to cotton are estimated to be 11 percent of global use (Fletcher, 2014). The cotton crop accounts for nearly a quarter of all the pesticides used in the United States. The United States, which is the third largest cotton producer accounts for one-third of the global trade in raw cotton (Meyer, 2019).The cotton crop in the United States benefits from subsidies that keep the prices low and production high. High production of cotton

subsidized at low prices is one of the first spokes in the wheel that drives globalization of fashion (Claudio, 2007).

China, which is also a major producer of cotton, is also the lead importer of cotton (Meyer, 2019). China along with other countries that have low labor costs receive the exported cotton where the material is milled, woven into fabric, cut, and assembled according to the fashion industry's specifications. China is the world's largest exporter of textiles (Hasanbeigi and Price, 2015), followed closely by emerging economies such as Vietnam (Nayak et al., 2019). Each year Americans purchase approximately one billion garments made in China, the equivalent of four pieces of clothing for every United States citizen (Rivoli, 2009).

Developing countries such as China, Vietnam, Bangladesh and Hati employ many workers in the clothing industry. Some of these workers make as little as 12-18 cents an hour and on top of that work in poor conditions. With the global competition and demands to lower production costs. Many of the factories are not regulated and may have safety standards on paper but in reality they are not enforced. On April 23, 2013, more than 1,100 garment workers died due to a building collapsing and over 2,500 people were injured in Rana Plaza, in Dhaka Bangladesh (Newman, 2017). Poor working conditions, low pay, and long hours for garment workers has long been a worldwide issue, but without events such as the Rana Plaza building collapse, social issues seem to be buried from the public view. Catastrophes, such as this one, bring attention to the hazardous conditions and human rights violations associated with clothing to the general public. As a result transparency has become an important issue for clothing brands. Due to the Rana Plaza disaster the group Fashion Revolution formed and launched a fashion transparency index, which comes out every year rating fashion brands on their transparency. Bringing awareness to the social issues and environmental issues relating to the fashion industry.

Clothing and its globally reaching impacts have prompted the United Nations in 2018 to include fashion and its implications as a focus area. The United Nations have included clothing as part of their Sustainable Development Goals (SDG) for better fashion. Addressing the environmental and social issues related to fashion production and consumption. The initiative "SDGs for Better Fashion" includes implementation of sustainable design strategies, promoting the use of sustainable technologies and appropriate resources management throughout the

textile supply chain, proposing new business models and engaging with consumers for better consumption habits (SDG, 2018). Creating goals to work with fashion retailers in ways to become more sustainable and reaching out to consumers to educate about the impacts of fashion is a great start to changing the industry and consumers behavior and attitudes toward clothing.

2.1 Microplastics and Laundering

Microplastics are a huge new concern with regards to the environment. Clothing is made from fibers, these may be natural fibers such as wool, cotton, linen or artificial/synthetic fibers such as viscose, rayon, cellulose acetate (Dris, et al. 2017). Synthetic fibers are made of petrochemicals and are included in the definition of microplastics. Microplastics have been showing up nearly in every environment. Microplastics pollution has become an ever growing problem in the last decade. This pollution has been widely observed in freshwater and marine environments worldwide. The main cause being from the rapid increase of plastic production. Microplastics are considered to be less than 5 mm in size making them available for interaction with biota at different trophic levels (Ivar do Sul, Costa, 2014; Wagner et al., 2014). Evidently these microplastics enter the human food web (Yang et al., 2013). Consequently, microplastics could create a threat on the growth, development, and reproduction of organisms once ingested (Wright et al., 2013).

Microplastics can be classified into two categories based on their sources, primary microplastics and secondary microplastics (Sundt et al. 2014). Primary microplastics are those released directly into the environment in the form of micro-sized particles, whereas secondary microplastics are micro-sized plastics particles originating from the degradation of larger plastic items during use, such as shedding from the use of synthetic textiles (Yang, et al. 2019). A third of microplastic pollution in the oceans comes from clothing (Cline, 2019).

Both natural textiles, such as wool and cotton, and synthetic textiles, such as polyester and nylon, may be released from domestic washing into the environment (Browne et al. 2011). Domestic washing has drawn attention as the most important source of microfibers to aquatic

habitats (Napper and Thompson, 2016). One single garment can release more than 1900 fiber per wash (Browne et al., 2011). Furthermore, 6 kg of textiles made from synthetic fabrics released between 140,000-700,000 fibers per wash (Napper and Thompson, 2016). Additionally, 75 percent more microfibers were released with the use of laundry detergent compared to just washing with water alone (Hernandez et at., 2017). The use of the tumble-drying cycle promoted a 3.5-fold increase in microfibers compared to washing alone (Pric et al., 2016). The Norwegian Environmental Agency reported that between 100 and 600 tons of fibers are released to the environment from laundries and households every year in Norway (Sundt et al., 2014). The International Union for Conservation of Nature has estimated that microfibers released from the laundering of synthetic textiles is the number one source of environmental microfibers at 34 percent (Boucher and Friot, 2017).

Synthetic fibers are released from clothing when washed at home and in the production mills. Up to 40 percent of these fibers are ingested by fish and mollusks, making their way up the food chain, to humans. In 2016, the Global Microplastic Initiative reported that 90 percent of 2,000 fresh and sea water samples contained microfibers and in 2017 Greenpeace found microfibers in the waters of Antartica (Thomas, 2019).

Microplastics are everywhere including our air. According to a study looking at fibers found in indoor air, 67 percent of fibers found indoors are from natural fibers and 33 percent contain petrochemicals (Dris, et al., 2017). These fibers are supposedly too large to be inhaled, but in time, new risks may arise due to exposure of microplastics in the air from textiles.

Laundering does not just release microfibers into the watershed. Up to 82 percent of energy consumption associated with an item of clothing is attributed to its post-purchase laundering (Fletcher, 2008). Americans consume 66 billion kilowatts of electricity per year just in washing and drying their clothes, this emits the equivalent of 46 million tons of carbon dioxide each year (Cline, 2019). One of the most energy intensive steps is heating the air for dryers, followed by heating water for the washing machine. There are ways to reduce this large amount of energy spent on laundering clothes. If consumers would take simple steps the amount of consumed resources could be greatly reduced. Some of the ways for the average person to reduce their energy output would be to hang dry clothes, stop using the clothes dryer, wash clothing less frequently, and only wash clothing in cold water.

Forced air, mechanical agitation, and heat from washers and dryers lead to shrinking, fading, and tears in clothing making its lifespan much shorter than possible. A study done by Senguen and Wolff-Mann (2013) found that after just 20 rounds of laundering and drying drying fabrics have lost about 50 percent of its tensile strength, making textiles twice as easy to tear. The average American runs a load of wash at least every other day, equiling between three and four hundred loads of laundry per year on average (Energy Star, 2014). Cutting the amount of laundry loads by just 10 percent would save as much as five thousand gallons of water per year (Janeway, 2017) as well as reduce the amount of electricity used. Of the energy consumed when washing clothes, ninety percent is used to heat water. By switching temperature setting from hot to cold can cut a load's energy use in half (Energy.gov). By simply changing consumer laundry habits, huge amounts of resources can be conserved, along with lengthening the lifespan of clothing items.

2.2 Clothing Disposal

Over the past two decades it has come to attention that the disposal of clothing has an environmental impact (Chen and Burns, 2006). Clothing waste is a large problem when considering that 3 percent of household waste is clothing waste (Fletcher, 2008). In the United States every two minutes a garbage truck's amount, approximately 13 tons, of clothing is dumped into the landfill (Cline, 2019). Over the last twenty years the volume of clothing Americans throw away has doubled from 7 million to 14 million tons, this amount is equal to 80 pounds per person per year (Thomas, 2019). The Environmental Protection Agency reported that in 2015 Americans sent 10.5 tons of textiles, the majority clothing, to the landfill. An increase of clothing disposal by consumers has been facilitated by faster changes in fashion along with a decrease in product prices (Majima, 2008).

The practical service life of clothes (how long the clothes are actually worn) is quite short, well below the technical service life (how long they could be worn, even if they are no longer in fashion), due to rapidly shifting fashion trends. As a result of fast fashion clothing may not be cared for properly and may be disposed of without much thought. These things make fast fashion an important driver of environmental impacts (Roos et al., 2015a). Beton et al. (2014)

reports, across Europe 10 percent of the clothing waste is recycled and 8 percent is reused, the rest are landfilled (~57 percent) or incinerated (~25 percent). In the United States the recovery rate for textiles has been reported around 15-16 percent (Wang, 2010: LeBlanc, 2017).

Clothing disposal behavior is defined as a consumer's decision to stop using a still-usable product and disposing of it in one of the following ways: giving it away, donating it, reusing it, selling it, storing it, lending it, or throwing it away (Jacoby, et. al., 1977). Depending on the disposal method some are considered more pro-social and/or pro-environmental than others. Recently, in addition to the classic forms of disposal, the use of technological platforms has emerged for the disposal of clothing and has been added to the so-called sharing economy (Lutz and Newlands, 2018).

The reuse of clothing allows consumers to meet their changing needs (Capellini, 2009). By reusing clothing, its useful life is extended, keeping clothing away from garbage dumps and landfill. Reusing clothing is a form of customer value creation and with this arises opportunities as well as threats for companies (Anker et. al., 2015). Reusing garments can reduce the environmental burden of clothing, the environmental burden associated with reuse of clothing is insignificant when compared to the savings due to replacement of virgin materials (Woolridge et al., 2006). Additionally, Woolridge et al. (2006) show the energy consumption of the retail and distribution processes associated with second hand clothing is much lower than the energy consumption associated with the production of virgin materials.

Reusing clothing can be seen as a customer value creation behavior. In Cruz-Cardenas et al. (2019) study several factors were revealed explaining the tendency of people to reuse clothing. The factors included income, occupation, altruism, and physical environment. This study also showed how various demographic groups such as lower income groups, younger individuals, students, and women had a greater tendency to reuse clothing.

Textile reuse refers to various means for prolonging the practical service life of textile products by transferring them to new owners, with or without modifications (Fortuna and Diyamandoglu, 2017). This can be done in various outlets such as renting, trading, swapping, borrowing, and inheriting, and can be facilitated by secondhand shops, flea markets, garage sales, online marketplaces, charities and clothing libraries to name a few examples (Sandin and

Peters, 2018). Various forms of reuse have been conceptualized in terms of collaborative consumption, product-service systems, commercial sharing systems and accessed based consumption (Belk, 2014).

Up-cycling was first coined by Reiner Pilz in 1994, meaning 'to grant more value to old product.' Up-cycling can also be described as 'recycling in rise in value.' Differing from down-cycling which is recycled in manner of losing significant part of existing characteristics or merits mainly while passing through mechanical and chemical processing (Choi et al., 2014). Consumers are practicing up-cycling, which is important in the era of fast fashion at home (Turker and Altuntas, 2014). Up-cycling has been found to be a great way to prolong the life of clothing and create a better sense of value. In a Focus Group interview done by Shim et al. (2018, page 14) they came to the following conclusion with participants who practice up-cycling:

"An up-cycling product is valuable with its scarcity, and could escape monotonous living by expressing their own personality, and enjoy high emotional satisfaction living as up-cycling becomes a hobby. Therefore, it showed that up-cycling raises cultural, social sustainability. They said they cannot easily discard up-cycling product they made and use them for a long time with affection. Like this sustainable characteristics of up-cycling appeared in families, and it is thought that up-cycling will be helpful in the creation of new values and developmental availability in sustainable clothing."

The targets of up-cycling are first to reduce waste, it repeats and circulates the life cycle of a product by changing its use in the final stages of the product life cycle, without going through the entire process of planning production and the consumption of a product. Sustainability is tightly linked to up-cycling while redesign reduces environmental impact and is in the principle of sustainable design, to rethink the design for realization of recycling materials circulation and symbiosis of humans and nature (Shim et al. 2018). Up-cycling minimizes the process by maximizing the function based on recycled wastes.

An increase in reuse and recycling of textiles could potentially reduce the production of virgin textile fibers and in the case of reuse, avoid engineering processes further downstream in the textile product lifecycle, further reducing environmental impact (Sandin and Peters, 2018). Textile recycling most often refers to the reprocess of pre- or post-consumer textiles waste for

use in new textile or non-textile products (Sandin and Peters, 2018). Recycled cotton fibers can be used in a variety of productions carpets, geotextiles, composites and nanoparticles (Chang et al., 1999), however with the existing textile recycling routes, textile waste materials are generally recycled into a lower quality material such as blankets or insulation materials (Sandin and Peters, 2018).

In recent years, some in the textile industry have made efforts in reducing the use of the natural resource cotton and have been trying to find a sustainable replacement for it. Some types of plastic and metals have been recognized to be the appropriate substitution for cotton. By collecting and reusing plastics in its recycled form it has two main advantages, one it makes the environment friendlier and saves natural resources by the way of reduction of consumption of virgin materials. Waste recycling is an effective approach to improving the waste management system and to reduce resource scarcity when globally utilized (Jafari, 2019).

2.3 Sustainable Fashion

Sustainability is defined in 'Our Common Future' as 'Satisfying the need of current generation while not impeding what future generation' (Merchant 1989). Using sustainability as a guideline to consider the impact of present behavior on future generations can direct long term views and behaviors. Ethical fashion has been defined by Joergens (2006) as fashionable clothes that incorporate fair trade principles with sweatshop-free labour conditions while not harming the environment or workers by using biodegradable and organic materials. Sustainable clothing has been described as 'clothing which incorporates one or more aspects of social and environmental sustainability, such as Fair Trade manufacturing or fabric containing organically-grown raw material' (Goworek, et. al., 2012).

During the last decade and a half sustainability has been recognised as an important issue in the clothing industry, increasing demand from consumers for products that are environmentally friendly and socially sustainable (Joergens, 2006). Most people are aware of some of the environmental dilemmas in fashion consumption (Oncioiu, 2016). However, consumers have limited awareness of the sustainability impact of clothing according to research

with consumers (Goworek et. al., 2012). Regardless, consumers being familiar with ethical issues related to fashion does not transfer over to responsible consumer choices. More than a decade ago,the slow foods and organic movement propelled people to be more informed about what they were eating and to contemplate the consequences of alimentary industrialization (Thomas, 2019). The same thing has not yet happened broadly with fashion.

Joergens (2006) Focus Group study focusing on ethical fashion found that consumers were not influenced by unethical business behavior or the way clothing was produced to influence their shopping behavior. This comparison sums up some of the participants' feelings, "Purchasing clothing is more complicated than purchasing fairly traded coffee. Coffee just has to taste good but not all clothing looks the same and fits to your personal style" (Joergens, 2016, page 362). Furthermore, even when people are aware of ethical problems in the fashion industry, that knowledge has little significance affecting their purchase decisions. The reasons for this behavior are firstly that people feel that they do not have a real choice since large quantities of their garments are produced in developing countries. Secondly, they do not feel they are in a position to judge about unethical behaviour of manufacturing companies in developing countries. The participants argued that Western norms cannot be imposed on the culture of the manufacturing country (Joergens, 2006). However, mindful consumers are more prone to purchase eco-friendly products: products practicing social responsibility, up-cycled products, and durable products for long time wear (Shim et al. 2018).

Sustainable consumption requires consumers to buy less, use products longer and produce less waste (Tilikidou and Delistavrou, 2004). The interest in sustainable clothing manufacturing and consumption has been growing rapidly, the size of the sustainable market industry implies that consumers are concerned about sustainability (Shaw et al., 2006). The clothing sector has reacted to consumer demand and sustainability publicity by introducing small scale ethical clothing retailers and launching sustainable ranges for the large retailers, many based on Fair Trade Production and organic cotton products (Goworek, 2012).

In a sustainable lifestyle study done by Vita et. al (2019) they found that sharing and extending lifetimes of clothes could diminish carbon footprint by approximately 3 percent. In their backcasting and visioning workshop they came up with four scenarios relating to clothing, animal free, durable fashion, natural fibers, and local clothing. They came to the conclusion that

the only net reductions in the consumption of clothing and construction may curb current impacts, while shifting materials offers modest reductions with possible trade offs. Durable fashion could halve the current impact of clothing, reducing the environmental footprint of Europeans by 1.8-2.5 percent by extending clothes lifetimes and increasing secondhand reuse. Lowering clothing miles by preferring local clothing reduces human toxicity by 1.7 percent due to the high toxicity of transportation fuels, with marginal reductions in other footprints. Replacing all synthetic fibers with natural fibers has a negligible mitigation process across footprints. Phasing out animal fibers for plant based and synthetic fibers would require 1.2 percent more land and 0.5 percent more water as shown with an animal free scenario. Choosing natural over synthetic clothing materials presents neglitible carbon reduction with potential back-fires in other footprints.

One way to immensely reduce environmental impacts of fashion is collaborative consumption, this alternative way of doing business, can prolong the practical service life of clothes. Defined as "people coordinating the acquisition and distribution of a resource for a fee or other compensation" (Belk, 2014). Gaining increased attention over the last several years, collaborative consumption is a part of the "sharing economy" (Belk, 2014). Collaborative consumption can include the renting, trading, swapping and borrowing of goods (Piscicelli et al., 2014). Besides collaborative consumption, many similar and related terms have emerged such as "commercial sharing systems", "product-service systems", and "accessed- based consumption" (Belk, 2014).

One of the current concerns with fast fashion is that consumers discard clothing before the end of its technical lifespan. A collaborative consumption business model within the fashion industry is the clothing library. Environmental benefits can come from inventions that increase the practical service life of a garment. Clothing libraries are beneficial in extending a product's life of service providing environmental benefits (Zamani et al., 2017). The clothing libraries typically consist of a monthly membership fee which allows members to borrow a specific number of clothing pieces for a set time, usually a few weeks (Zamani et al., 2017). Looking at two perspectives, first the user, clothing libraries can maintain or even increase the speed of fashion, each user may update their wardrobe at least as frequently as with conventional fashion. The second looks at the perspective of the clothing, clothing libraries can slow down the spread of fashion, assuming that each item is used more times before disposal compared to

conventional fashion consumption. Looking at the clothing perspective clothing libraries can prolong the practical service life of clothing items which, inturn, can reduce the production of new clothing and the associated environmental impacts (Zamani et al., 2017).

As a form of collaborative consumption renting clothing has also been gaining traction. Rental services began by offering clothing for formal events. In recent years fashion rental services have expanded to trend driven everyday fashion apparel. Some people only wear a piece of clothing three times before considering it old. Through the medium of rented clothing the consumer has the satisfaction of wearing something new to them, while knowing the environmental impact is reduced. Renting can increase the practical life use of clothing by up to 900 percent, and then can be sold after the rental company feels it is out of fashion (Cline, 2019).

Second hand clothing is also a form of sustainable fashion. Giving clothing a second chance at life. The environmental impacts of second hand clothing is close to none, it has already been made and used and without the second life would be destined for its end. ThredUp the world's largest online second hand shop has been promoting the environmental advantages of buying second hand. If everyone bought one used clothing item instead of new this year 25 billion gallons of water, 11 billion kWh of energy, 5.7 lbs of CO2 emissions, and 449 million lbs of waste would be saved (Thredup, 2020b).

The popularity of buying second hand is also growing. In 2017, 44 million bought second hand products and in 2018, 56 million people bought second hand products (Thredup, 2020b). Second hand shops can be associated with consumption rather than frugal consumption, due to the changing shopping habits of consumers, second hand is considered a regular shopping outlet along with online shopping and malls for younger generations (Nistor, 2019).

Need and choice are factors that divide customers who shop second hand according to Xu et. al. (2014): buying from secondhand shops can be a utilitarian necessity in the case of consumers living on a small budget, who do not have opportunities to go shopping, but it can also be a lifestyle choice by means of voluntary simplicity and adventure seeking. Among the major reasons for frequenting a second hand shop are, according to Roux & Korchia (2006), environmental concerns, price consciousness, esspecally in the context of economic

constraints, socialization (when items are bought from flea markets), nostalgia (e.g. vintage clothes), the rejection of consumerism, smart shopping (getting branded product for a good price, and search for uniqueness.

Obstacles that prevent consumers from buying clothes from secondhand shops, once again from Roux & Korchia (2006), are contamination, fear of transmitting germs and diseases, lowering self esteem by wearing previously worn by others, form of disposition (i.e. Borrowing other people's identity). These obstacles can be overcome with outreach and education.

3. Trends

Trends in the fashion industry and those that affect the environment are developing and ever changing. Tracking trends during 2019 and early 2020 different trends have emerged some of these building off of concepts before this time period. Current trends range from how clothing is bought or rented, to technological advances that could or could not lead into the future of clothing. Trends are responses from the fashion companies for what they think the consumer would like to see them do or want to feel when they purchase their clothes. Trends also look at the attitude of consumers and what they are currently wanting, leaning towards, the image they would like to portray with the clothing they wear. The following trends vary from research being done at Universities, to technological changes, to the way in which shopping for clothing is shifting. Many of these trends fit into more than one category and that's the way the world works stretching and flexing into multiple aspects of life.

3.1 Technology

One of the first trends to stand out is technology and how it is shaping the clothing that is produced can be multifunctional. Researchers at the University of Malaga and the Italian Institute of Technology have teamed up and created non toxic spray from tomato skin, ethanol, carbon nanoparticles and water that when applied to a cotton tee shirt converts 'waste' heat from our bodies into thermal power. The shirt can currently power LED lights and the scientists are currently working on how to use the tee shirt to charge cell phones or even embed wifi into it. This could potentially change the way our clothing functions, providing multiple uses for a

common item. Reducing electronics and using an energy source we all have at all times, our body heat (University of Malaga, 2019). These charging t-shirts are not in mass production yet but have the potential to reduce the amount of energy used by using energy that was previously unused, our body heat. At this time almost everyone has a cell phone and needs to keep it charged with this shirt charging by heat produced by a body. This technology may motivate more people to go outside and do something active, capable of powering their cell phone, offering a double incentive for working out.

Other trends incorporating technology include Spaniali Design and Sensoria along with others. These clothing types can be labeled as "smart clothing." The clothing company Spinali Design has connected clothing to technology by creating an app for their smart clothing. For example their jeans have built-in sensors that will vibrate on the left or right side of the jeans when you are navigating directions to get somewhere, there is no need to pull out your smartphone and look at the map you just follow the vibrations. On swimwear there is a function that will alert you when you need to apply more sunscreen. They have also designed dresses and other clothing that will function with their app to alert the user of many options for the user to decide on. By connecting a smartphone to the clothing app, the clothing guides you to what you would like it to alert you for. This hand free approach is attractive to those who do not want their phone out all the time.

Similarly, technology embedded into smart socks promoted by Sensoria, have incorporated a virtual coach that can help improve running form and foot landing technique. By way of microelectronics, software and sensors incorporated in the smart sock to help measure how far and fast you run with precision. The socks also allow you to analyze the shoes you are using based on the data received from the smart sock. The data is shareable making it easy to give your data to others. These socks are part of a movement titled 'internet of me' gathering and collecting your data in order for you to make more informed decisions in the future. This same technology has been incorporated into active wear such as smart yoga pants by Nadix. By gathering data about your posture and movements personal data collected can be informative for athletes as well as the home enthusiast working on improving their skills.

Educating the consumer on the environmental impact of clothing is one major way to turn the industry standards and make people aware of where their clothing comes from and

where it goes after they are done with it. ThredUp has launched a free quiz on their website, for helping shoppers evaluate the impact of their closet on the environment. The quiz, 'How Dirty is Your Closet' asks questions about the user's purchase frequency, number of items repaired per year and laundry habits (ThredUp, 2020a). The results are an estimate of the users wardrobe's carbon footprint in comparison with the average consumer, they then receive advice on how to reduce their footprint in the future. Providing a sense of what an individual's clothing footprint is can help bring awareness to the impact clothing has reminding people to be mindful when making decisions about clothing.

As society becomes more aware about the impacts of microfibers as a result of clothing, it is recognised that solutions must be made to keep microplastics from entering waterways. Arcelik, a Turkish home appliance manufacturer, announced a new washing machine aimed at keeping microplastics out of the ocean. The machine targets tiny micro plastic fibers that are released when clothes are washed, they claim that it captures 90 percent of those fibers. According to the Arcelik around one million fibers are released during a load of laundry. These fibers end up in the water system and can be ingested by fish, animals and people. The company plans on open-sourcing its filter technology enabling other appliance brands to incorporate this technology (Arcelik, 2019). With open sourcing this technology it could be a game changer with the amount of microfibers that are released into the world's waterways, drastically reducing future risks and problems associated with microfibers.

With smartphones being used as an everyday item many apps have been created in order for people to know what is in their closet. The app Cladwell keeps an inventory of the clothes you own, helping you create different outfits and keep track of what you are wearing on a day to day basis. By helping you create a capsule, the goal of Cladwell is to help simplify the personal wardrobe and increase that amount of times clothing is worn (Cladwell, 2020). This and other apps similar can help reduce the amount of clothing waste. Other apps have been developed to help the shopper find out if the brand they would like to buy is sustainable. Good on You app ranks the ethics and sustainability for fashion brands from "great" to "avoid." With this app you can search for specific items and it will lead you to the most sustainable brands. Other similar apps such as Done Good and Rank a Brand rank brands as well. Providing transparency for the consumer to make smart decisions about what they chose to acquire (Cline, 2019).

3.2 New Innovations

New innovations are changing the fabrics being produced as well. Modern Meadows, a pioneer of biofabrication, are looking at the correlation between design, biology and material science evolved in making materials for a healthier planet (Modern Meadow, 2020). Modern Meadow is growing leather-like material in labs. According to Modern Meadow employee, Suzanne Lee, "We program the DNA of yeast to make collagen, so the yeast cells become a little collagen-producing factory. We're teaching an old process new tricks" (Thomas, 2019, page 199). This is a bio fabricated material that looks and feels like leather. Looking at the final product through a microscope it is leather but it can not be called leather because it doesn't come from an animal. This technology could slowly start to replace industrial farming which is horribly polluting on many levels.

Looking for environmentally sustainable solutions in the fashion industry is allowing companies to think outside the box and come up with creative solutions and ideas. A $110 USD t-shirt was launched by Vollbak a UK based apparel brand (Vollebak, 2019). What's so special about this t-shirt? Well it will decompose in 12 weeks if composed or buried outside. This shirt is called Plant & Algee, the material is made from a combination of sustainably-certified wood pulp and the ink is 3D-printed from algae. The algae oxidizes as the shirt is worn, so the shirt will decolor over time. This process gives the wearer a one of a kind look and promotes environmentally friendly clothing. Currently there is a waiting list to purchase the shirt. The demand shows that there is consumer appeal for sustainable clothing and they are willing to pay for such innovations. This shirt's adaptive design offers consumers an eco-status. Although this shirt is quite expensive today innovations such as these may become less expensive and play out as a popular solution for the future.

While technology can change the way clothing is manufactured and produced there is also a side that can shine on environmentally harmful processes and reduce the impact or transform the way things were done into a new process. The popular US based brand Wrangler introduced a new foam-dye process technology called Indigood. This process is eco-friendly and sustainable, eliminating the need for water in the dyeing process. It also reduces the energy

use by up to sixty percent. The process uses foam created from a chemical free soap agent to transfer the dye into yarns to produce clothing. This process does away with the traditional water vats and chemical bathe required by conventional indigo dyeing (Wrangler, 2019). By sharing the process of Indigood this could play a major role in reducing the amount of water used in the fashion industry, pollutants exposed to workers and the water stream, and reduce energy intake. If processes such as this are adopted throughout the manufacturing process it would dramatically reduce the environmental impact.

3.3 Custom Fit

Custom fit is another trend that has appeared numerous times during the past year. With the advancements of using technology custom fit can be achieved faster than ever before, appealing to consumers who would like their clothing to fit perfectly. Unspun, a startup based in San Francisco, sells only made-to-order jeans. Unspun does not carry inventory due to the nature of the business, partnered with Fit3D customers undergo a 20 second body scan that measures the body and then a 3D weaving machine creates the product (Unspun, 2019). There are many benefits to this process, one of them is that it eliminates fabric waste and provides the perfect fit of custom jeans and second is that inventory is not created, shipped and stored waiting to be sold. This provides sustainability with personalization for the customer. H&M Foundation is one of the investors, showing an interest in these types of products provides some hope fast fashion may be shifting into a new direction at some point and may move forward with this type of fashion.

Custom fit applied with technology has many great advantages. Apparel brand Ministry of Supply has partnered with the Self-Assembly Lab at MIT to create instantly tailored sweaters for customers measurements. The new service combines a robotic heat gun and sweaters made from a special fabric that will shrink when exposed to heat. This provides a custom fit specifically for the owner (Ministry of Supply, 2019). The target of this project is to reduce manufacturing of different sizes in mass fashion. Again, making a product mainstream with the advantage of a one size fits all until customized gives the manufacturer the opportunity to

streamline the product without the fussiness of making a bunch of different sizes of the same piece.

Apps on a smartphone are also being developed to help provide a custom fit along with getting the right product for your specific interests. Nike has announced a new app called Nike Fit. This app allows the user to measure the size and shape of ones feet determining the perfect fit (Nike, 2019). The virtual fitting room is not a new concept but with the ability to scan the body you get a more accurate fit. This is also a way to keep consumers entertained while trying on products. By the use of virtually trying on products there is no need for a brick and mortar store by purchasing products knowing they will fit will give consumers peace of mind and returns will be lower than traditional online shopping. Virtual fit is not the only type of innovation taking place in house retailers are also changing the way they serve their customers.

While the shopping mall and brick and mortar stores used to be the go to source for shopping many consumers have now preferred online shopping (Ritzer, 2012). Internet shopping has been steadily on the rise. The problem with online shopping for clothing is that clothing can not be tested or tried on before purchase. As a solution to this problem Mayntra an Indian fashion ecommerce platform is employing local tailors as last-mile delivery agents, and allowing them to be the last step in making sure clothing is a perfect fit. As a way to minimize the cost of returns and refunds the tailors can provide on the spot alterations for ill fitting items. In India it is a common practice to take online clothing perches to a tailor, this reduces time for the customer and streamlined experience (Mayntra, 2019). Providing a customizable piece of clothing on the spot without the hassle of leaving the home may be an appealing option to those in other places as well.

3.4 Experience

Being able to try on a product before purchasing is not a new concept, but being able to try the product in the climate in which it is to be used is. In Toronto the outerwear brand Canada Goose opened The Journey a zero-inventory store. The store has incorporated an artificial room that mimics outdoor weather with a temperature of -12 degrees, snow sounds of crackling ice and a nature video, where you can test their products to get an authentic feel for what the

product will be like when you are out on an adventure. If the product is something you would like to purchase, you order digatly and it is delivered the same or the next day. There are major benefits of being able to try clothing in a realistic environment.The customer is more confident in the product knowing how it functions, which then leads to a reduced amount of returns.

Specialty gear, such as cold weather mountionaring clothing, has nearly been impossible for the customer to try out until it was purchased and then used by the owner. This new way of testing is an interesting concept to let the customer be in the element with the product. This concept also reduces the amount of inventory on hand at the retailer location. Being a zero-inventory store shifts all products to a central location where it is then shipped directly to the consumer's home. Direct shipping of purchases to the customers home leaves space to the retail location to incorporate artificial climates for testing.

3.5 Transparency

Transparency is one step that most consumers are missing when they would like to find out where their clothing comes from. The supply chain is long and even hard to track for the manufacturers. Many brands have some information available but clearly not everything. In order to change that in May of 2019, Google X and Stella McCarthy announced a sustainable fashion pilot program. This program uses Google Cloud data analytics and machine learning to give the brand a more detailed view into its supply chain. The program will analyze data to better measure the impact of the raw materials in relation to key environmental factors such as air pollution, greenhouse gas emission, land use and water scarcity (Google X, 2019). Google is focused on the raw materials phase of fashion production due to the high environmental impact of this stage. This is an innovative way of using big data and eco-data science to enlighten the producer of products and make meaningful changes to their production. It also inspires transparency to be used, and as a result, wise consumers will be informed and make more environmentally friendly products.

Many attempts are being made at reducing the environmental footprint of clothing, while also adding transparency to their products. One example of this is Sheep Inc. a UK based

brand. Sheep Inc. announced that it would become carbon negative by investing 5 percent of its revenue into biodiversity projects to offset the carbon impact of its sweater production by tenfold. Customers who buy one of their sweaters also get to adopt one of the sheep who lives at the farm the wool comes from. They will receive updates on the sheep's daily life such as health, when it is sheared or if the sheep gives birth, on a regular basis (Sheep Inc., 2019). This gives the customer personal insight to the product, providing transparency and provides an eco-boost to the environment because of the purchase.

The more information generally available is helpful when making decisions for all concerned parties. The high end fashion brand Gucci's CEO, Marco Bizzarri, initiated the CEO Carbon Neutral Challenge which calls leaders across the fashion industry to commit to a carbon neutral future. When a company joins they commit to a full audit of its greenhouse gas emissions within one year, and commit to six principles that will lead to a reduction of its carbon footprint (Gucci, 2019). Green pressure can help play a role in the fashion industry, by motivating others to be responsible and take part in initiatives such as these.

3.6 Collaborative Consumption

Trends are not just occuring in the retail arena. ThredUp an online fashion resale company has stepped in to see that all clothing reused. In August 2019 they announced a new service aimed at helping retailers join the resale revolution. Resale-as-a-Service (RaaS) provides companies with the process they need to participate by donating shipping labels, to resale pop-up activations, and store credit for shoppers who sell their second hand goods. They also announced 175 million US dollars will finance this endeavor (ThredUp, 2019). This is beneficial because it helps create a closed loop system and helps the retail sector enter into the sale of second hand. Providing retailers a way to get into the second hand market will make clothing last longer living its potential life.

Renting clothing is slowly gaining momentum in the mainstream arena, this idea has been in place to extend the life of clothing by making it available to many users. In December 2019 W Hotels teamed up with Rent the Runway, a fashion rental company, to launch Closet

Concierge, a program that lets hotel guests rent outfits to wear during their stay. This service allows guests to pack less for their trip and has some trickle down sustainability benefits. A few of these benefits could include packing less for a flight which could lead to lighter, more fuel efficient flights and the reduction of textile waste (Rent the Runway, 2019).

4. Environmental Scanning

Wild cards or black swans can play a huge role in the world, as recently seen with Covid-19. Basically, shutting down the entire economy and having a huge proportion of the Earth's population staying at home. This has also had a major impact on the way clothing is produced and sold. Halting the demand for recreational fashion needs. Recently many major fast fashion and high end retailers have announced they would produce personal protective equipment (PPE) to help the effect of the medical personnel in this pandemic. Shifting production to produce PPE rather than the normal fashion these companies normally produce will be a major influence on the supply of personal protective equipment for the medical emergency teams helping with the Corona outbreak. This show of support also will carry on and shine a good light on the companies which are helping out at this time. By supplying to those in need at this time of crisis the ethical view will be changed with some of the companies. Showing and supporting the world in its time of need shows selflessness and caring toward humanity rather than just care for profits.

Fashion trend forecaster Li Edelkoort has said about the current situation "It seems we are entering a quarantine of consumption where we will learn how to be happy just with a simple dress, rediscovering old favorites we own. Reading a forgotten book and cooking up a storm to make life beautiful" (BoF, 2020). Uncertain time can lead to changes that start within. People are realizing they have what they need and are satisfied. Also this time period will spark new ideas and solutions that have come from the unknown. The fashion industry will look different coming out of the lockdown due to the pace of the economy. Unknown effects will be revealed in the years to come, but changes will certainly take place.

Other effects of the great lockdown that may linger are the amount of garment workers who will be unemployed for a long period of time and possibly never to be employed in the industry again. Robot and machine production may take a greater role in the industry due to the social distancing factors people have had to maintain during the outbreak. With fewer employees working on the production line the human interactions will be reduced and manufacturers will have less responsibility for a large number of employees.

The price of cotton has also been greatly affected. The prices of cotton have declined almost 30 percent in the first four to six weeks of the lock down. The low prices for cotton are making farmers consider not planting this year's crop. The results would be a lack of the resource or the prices would jump making clothing which is made of cotton cost more (Shurley, 2020). Results could also be an increasing development in recycling fibers or developing new more cost effective synthetics or combinations of fibers. The environmental implementation of fallow fields would mean less fertilizers and pesticides being used. However empty fields could lead to a dust bowl. The situation is surely going to impact the fashion industry as well as the environment.

Climate change has been in popular media for some time now. In the past year climate activism has been gaining momentum in action and popularity. Actions taken, such as *Fridays for Future,* led by youth leader Greta Thunberg have highlighted climate change urging governments, corporations, and individuals to take action. Movements such as this are highlighting changed people can make to lead to slowing climate change. Clothing and its role in climate change is large from the way cotton is grown and fossil fuels are used to make fibers for clothing. Along with the transportation of the supply chain for manufacturing clothing. By bringing awareness to the general public on the environmental issues clothing creates will lead to wiser choices. The activist group Extinction Rebellion has called a fashion boycott, with participants to go one year without buying any new clothing items. Eurging participants to repair, re-use, alter, upcycle, recycle and only buy used clothing as an act of collaborative action to mitigate fashion's impact on people, planet and animals. They are hoping to disrupt business-as-usual by sending a message to the government, industry, and the public that practices in the fashion industry need to change (Leach, 2020).

The year of 2019 in Hong Kong was a year of protest. Many people took to the streets demanding freedom from mainland China. The uniforms of the protester consisted of black clothing, face masks, and umbrellas. The black clothing was a way of recognising a fellow protester, the facemask was a way to hide from the widespread mass surveillance in the city of Hong Kong, and the umbrellas were used as a way for people to protect themselves from tear gas and rubber bullets (Glass and Berry, 2019). Clothing used in a way of covering up identity in the forms of facial recognition and surveillance cameras, is slowly emerging. Anti-surveillance stealth wear made to thwart thermal-imaging cameras, by using silver plated synthetic fabrics that are flexible, wearable and thermally reflective have been developed recently. This type of clothing makes it harder for aerial surveillance drones' heat sensing cameras to see the wearer. Along with light-emitting accessories such as purses, hats and umbrellas, that wash out unwanted photographs to confuse some optical sensor systems. Other forms of clothing are being developed to block wireless signals (McDonald, 2019). As some governments turn to more forms and stronger surveillance, people who want their privacy will be attracted to clothing that helps protect them.

On the horizon is a multitude of ways to reuse clothing. Many projects are taking place to turn discarded clothing into building materials. By turning used and unwanted clothing into building materials instead of discarding to the landfill or incineration, creates a valuable, usable product once again. Studies being done at the University of New South Wales in Australia by Veena Sahajwalla and her team have been working on creating building materials from discarded clothing. The process involves collecting assorted garments then removing zippers, buttons, buckles and all other solid applications, leaving only the fabric. The fabric is then shredded into fibers resulting in a fleece. The fleece is then treated with chemicals and compressed under heat to form solid panels. The panels have proven to be strong water-resistant and minimally-flammable. The panels created had different colors and textures resembling wood ceramic or stone depending on the mixture of components used. These panels have the potential to be used as floor tiles, wall panels or other interior finishes, they also have strength which could make them suitable for load-bearing applications. The end product is comparable to wood-based particleboards (Echeverria, et al. 2019). This is the first study to turn clothing into a solid application for building materials, but other researchers in Europe are also working on recycling clothing into soft mats to be used as heat and noise insulators inside floors, walls, and ceilings (Klein, 2018). As more research is done and these products become

commercially available the demand for waste clothing will increase and landfill disposal for clothing may become obsolete.

5. Scenarios

The following three scenarios are derived from trends, horizon scanning, creative thinking and creativity. All three scenarios use the year of 2030 as a guide. Taking into account that these scenarios are not set in stone and are flexible within each realm. Changes that are unknown do occur and timelines do not ever play out exactly as thought. These scenarios are a possibility of what the future of clothing and its environmental impact may look like.

The Steady Mix is a scenario projecting business as usual with some of the trends taking hold. Many of the aspects of Steady Mix are a combination of the trends, This scenario portrays what things will look like in 2030 if the fashion industry keeps working like it does today. Slowly environmental improvements are made and human rights are improved. Some of the key factors forming Steady Mix are a slow process of change, while money and the economy are a driving factor for the indistery, policies are similar to what they are today, technological improvements decrease the amount of waste produced while also improving speed at which things can be done. Many of these features are done to boost the economic side of the fashion business. This scenario can be considered the probable scenario for where clothing is headed for 2030.

The second scenario, Custom Fast Fashion, is a scenario based heavily on new technologies, but without the environment as a priority. Factors that have gone into this scenario are largely based on the custom fit trends. The current pandemic shaping the way people buy their clothing and retail shops rethinking the way their space is used. Economic prosperity for the fashion industry where they are still focused on the fast fashion model. Environment has taken a side line to economic well-being while policies are money driven. The Custom Fast Fashion scenario is considered a possible scenario for 2030.

The third scenario, Environmental Action, is a scenario in regards to the environment where consumers, policy makers, and corporations take major actions in creating

environmentally friendly policies. Global awareness is abundant in this scenario. Creating an environmentally friendly industry as well as people choosing to reuse and dispose of their clothing in a sustainable way. Actions that have formed this scenario are pro-environmental policies from governments, industries, and individuals. This is the prefered scenario for 2030.

5.1 Steady Mix

The fashion industry is one of the leading in the world. The sector employs a large amount of the world's population. Robots excel in sewing and producing garments although the final inspection is still done by humans. Specialty technicians are on hand to repair and update the robots. The use of robots has boosted production pace and more products are made faster. Little waste is produced due to the precision of the automated labor. The supply line is stretched around the globe. Notably, China has the most advanced and productive system for getting products ready the most efficiently. Other nations are still using the old technique of human labor in the factories.

Wages for textile workers vary. Minimum wage is still average pay for most laborers in the factories, but is higher for skilled jobs. Specialty training is needed for such as repairing and maintaining the robots. These jobs are in high demand and come with high pay. The process of dying fabric has been revolutionized with the waterless dyeing process most dyeing plants are using today. Large amounts of toxic waste are no longer washing into waterways as it once was.

Transparency is apparent in all the major brands as well as most small brands. Human rights and environmental regulations have become more visible. Some clothing manufacturers have become carbon neutral as a way to reduce their environmental impact. The fashion rental has become a staple for vacationers as anything but a small carry on is very expensive to take on an airplane. Renting clothes has become a way for people to keep up on the latest fashion trends and is used by a large portion of the population.

The value of clothing has become slightly higher than it was in the past due to the advanced manufacturing processes. Specialty clothing containing the technology to convert thermal heat from the body into power for charging phones is readily available. As well as

clothing meant to divert attention from prying eyes. The amount of electronic surveillance has intimidated many people and they prefer to use their clothing as a shield from the surveillance.

Resale clothing is a huge part of the fashion economy with more than a third of people looking for what they need at a resale shop before buying new. Changes in attitudes have prompted some people to buy used before new. Resale for clothing has been steadily increasing both online and in brick and mortar stores. In large cities pop-up resale shops have become popular, with customers flocking to them as themed and rare items tend to be found there. and donate or use consignment to sell clothes they no longer want.

People are able to drop unwanted clothing off into the clothing recycling bins which are located throughout most cities, towns, and villages. Discarded clothing is then used in a multitude of ways. Sorted clothing makes its way to a variety of destinations. Clothing is then destined to be resold, recycled into fibers or turned into a lower end textile product. Some of the discarded clothing is shipped and used in making construction materials. Some clothing still finds its way to the landfill or incinerator but not nearly as much as in the past.

5.2 Custom Fast Fashion

Custom fast fashion is leading the fashion industry. Smartphones have become the tool of managing clothes as well as the preferred way to shop. The process for purchasing clothes is convenient and the customer now will receive something that fits them well. Brick and mortar fashion stores are few due to online shopping, but some small versions are still standing as a place for the customer to come and get a customized body scan. The body scan will take the person's precise measurements and store them in their personalized database. The store and customer have access to the measurements when they are deciding what to purchase online and can make sure they get a perfect fit every time. Smartphones also have the ability to do body scans, but the brand does not guarantee a 100 percent perfect fit with the app and prefers customers to be scanned in person at the store. 'Smart' purchases are automatically added to the users closet inventory app. This app gives the user suggestions for future clothing items and accessories that will fit well within their wardrobe. With a tap the item can be ordered.

Warehouses used as distribution centers are now known as well the customization centers. When a product is purchased the one size fit all garment is placed on a mechanical form that shapes its size to the calculations of the customers body scan and then heats up to resize to the perfect fit, before it is sent out. This process only takes minutes and then is ready to ship. Drone delivery to the customers front door is quick and reliable. Most casual items can be ordered and received within 24 hours. This customization process has reduced the amount of waste due to over manufacturing, but has created other problems as well. One of the issues being that if the client does not like the product the process for resizing has already been made, and cannot be undone. The fabric is also tricky because it will not biodegrade, but there is a recycling process it can go through, the problem is getting it to the right place when the owner is done with it.

Natural fabrics such as denim, linen, and leather are also being used in creating custom clothing. The process uses the body scan as well and then the fabric is cut out and sewn according to the measurements. This process takes up to a week due to the lack of one size fits all garments in natural fabrics. Adapting to the custom process was surprisingly easy for shoppers and even better for the fashion brands. The retail space is now much smaller than the past traditional shops, requiring few employees, and convenient for the consumer who can make an appointment for a scan. The online catalog is updated regularly and frequently alerting registered users when new products are available.

The custom fast fashion industry is thriving and making some strides in becoming more environmentally friendly, but the main focus is on making products people think they need. Some brands have social and environmental goals, but more can be done. Government policies are lenient on the fashion industry. Clothing waste is a problem without proper recycling methods widely in use. And the attitude of the average consumer when it comes to clothing waste is 'out of sight out of mind.'

5.3 Environmental Action

After government regulations went into place due to the demand of people to slow climate change and protect the environment. Clothing has become a valued resource that is

made well, reused, and recycled. Many new fabrics have been developed that are 'green,' reducing the amount of pollutants used to produce and develop fibers.

Transparency of where clothing comes from has become mandatory for all stages of production. Clothing is required to have a QR code on the tag so anyone can see the environmental impact of the article from the production to shipping. This is rated in different categories so the consumer knows what kind of impact the product had. This change has come with some push back from manufacturers, but the demand from government, customers, and social and environmental advocates have made this step mandatory. Along with the steps of where the clothing came from are suggestions of what to do with the item when you are done with it. Some brands are requesting that you send the product back to them where they will fix any imperfection or upcycle the product and resell it to extend the usable life. Others suggest you donate it to a second-hand shop, where it can have a new owner. These suggestions have helped reduce the amount of clothing that ends up in the landfill. The aim of transparency has changed the way the culture thinks about clothing making it a more valued commodity, while prices of clothing are slightly higher than they were in the past, the people who sew, dye and process the clothing are paid a living wage and can support themselves and their family. Better transparency undoubtedly helped bring an awareness to the consumer that there are real people behind the products they buy.

Online clothing swaps have become widely popular. Trading clothing for credit on a point based system allows you to send out the clothing you do not want to someone who does and then you can get something you want from anyone on the site. This bartering is free for the users and pays only shipping costs if they cannot pick up in person. You can search for items on a local or global scale. Clothing has become a fun way to bring the community together with clothing swaps in person. Upcycling workshops and videos are hot as people want to tap into their creativity when repairing their own clothing.

Because of the huge amounts of micro plastic found in the food system and oceans new washing machines are required to have a micro plastic filter which reduces the amount of microplastics that reach waterways by 90 percent. All newly built laundering machines have been equipped with this feature. Although this does not remove existing microplastics from water it has steadied the situation as a solution to remove the particles are being developed.

This household appliance has been slowly replaced as people become more aware that the process of washing their clothing is the major contributor to micro plastic contamination.

Clothing is perceived as something to be reused and then recycled. The construction industry has adopted the use of building materials made from shredded fabrics. This drastically reduces the amount of clothing that goes into the landfill to almost zero, Clothing is collected and bought at recycle centers and shipped to the proper manufacturers to turn it into construction materials. These materials are then used in new and remodel construction. This cloth board is gaining popularity and can be speciality ordered from large hardware stores for the general public to use as well as commercially available for construction. Many people have been excited to use this product choosing it over its counterpart wood, because it is a recycled sustainable product.

6. Conclusion

The main objective of this thesis was to use foresight methods to create scenarios on the topic of clothing and its environmental impact in the future. By examining the history and past technological changes, demonstrating that society progressed in order to advance clothing and its manufacturing processes. The industrial revolution established the rapid changes and technologies that we have improved upon and are still using today. Policies and trade agreements help to develop the fast fashion era leading into the current era. With the fast fashion era the amount of clothing being made and discarded has become tremendous. Leading to clothing having a negative environmental impact.

The current environmental impact of clothing is broad. Laundering synthetic fabrics has led to the unintended consequence of leaching microplastics into waterways around the world. Microplastic are found in animals and the consequences are still widely unknown. The way clothing is disposed of also has an environmental impact. The more times a piece of clothing is worn the least impact it has. Collaborative consumption helps in making sure clothing is used to its practical end life. Sustainable fashion choices for manufactures and consumers is an important way in demonstrating support for social and environmental issues associated with clothing.

Many trends in fashion are geared toward technology, new innovations, custom fit, transparency, and collaborative consumption.   Transparency and collaborative consumption are the most promising to make a positive effect on the environment, but all areas have positives as well as negatives. The environmental scanning process found elements that may be coming soon that are not yet so apparent they can be considered trends. Elements form trends and environmental scanning were then combined to create three scenarios of the possible future.

The three scenarios developed from trends, environmental scanning and creative thinking are different ways to think about how the future could look. The first scenario Steady MIx is considered the probable future without any great changes. This scenario was thought-out as business as usual. Steady Mix has some advances toward sustainability and transparency, but a slower pace than what is seen in scenario three Environmental Action. With advancements in robot production saving time and materials, but driving forces being business. The resale sector continues to grow which is a good implication that people are changing their fast fashion shopping habits. Technology has appeared in clothing and is widely used, that transfers thermal energy into power to charge phones, making clothing multifunctional.

Custom Fast Fashion is a future focused on production and profits. This is a possible future where fast fashion continues to dominate the clothing market. Technologies will be used to customize fast fashion to specific individuals sizes while manufacturing can be mainstreamed for a one size fits all model. The retail shop as we see it today will be transformed In part to the current pandemic and more to online purchasing. Without environmental issues being a priority they will fall to the wayside, manufacturers being more focused on the money their products bring in. While the average consumer does not really consider where their clothing comes from or where it will end up when they are done with it.

Lastly Environmental Action is what could happen if policy changes are made that will lead to a sustainable future. This prefered scenario looks at what pro-environmental policies and action would look like. Creating a circular economy for clothing and lengthening the used lifespan. Transparency is readily available for those who would like to know where their clothing comes from and what they should do with it when they are done with it. Also micro plastics generated from clothing and introduced into the waterways have been reduced due to

technology incorporated into all new laundering processes. Clothings impact on the environment has been reduced and little of it ends up in the landfill or incinerator due to the demand for unusable clothing being reused and turned into building materials.

To conclude the future of clothing and its environmental impact is uncertain, but the scenarios can help provide a glimpse into what the future may look like. As society progresses and technological changes are discovered and adopted, the impact of clothing on the environment should decrease. Future steps that will improve the textile manufacturing industry are benchmarking environmental performance for policy-makers or manufacturers and adopting and investing in new technologies that promote environmental and economic improvements (Chen, 2019). The process leading to change depends on multiple factors, one of those factors being the choices individuals make.

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