Design for Sustainability in Fashion Accessory

How sustainable design methodologies are applied to the design process

Trinh Bui¹, Alba Cappellieri², Berill Takacs³

¹maitrinh.bui@polimi.it
²alba.cappellieri@polimi.it
³berill.takacs.17@ucl.ac.uk

Abstract

The fashion industry has become one of the most polluting industries in the world. Nevertheless, designers can contribute to solutions by applying Design for Sustainability (DfS) criteria, which enable and promote the design of more sustainable products and services. Therefore, the “Slow Fashion” movement has been receiving the attention of researchers, designers and customers who are concerned about sustainable development. The purpose of this paper is to contribute to a better understanding of Design for Sustainability in fashion. In particular, how sustainable design principles can be applied to Fashion Accessory in order to minimize the negative impact on the environment and society. The research method of this study is qualitative, utilizing a multi-method case study approach. Grounded theory analysis was applied to analyze the data from the case studies and to obtain the results. The research findings indicate that Design for Sustainability applied to the Fashion Accessory design processes might have great potential and win-win approaches toward a sustainable future. An important implication is that understanding the concepts and applying DfS to fashion accessory design processes can support designers to face challenges and seize opportunities. Furthermore, identifying the key concepts of sustainability and social responsibility could raise awareness on sustainable fashion among both producers and customers more effectively.

Keywords: Design for Sustainability, Fashion Accessory, Sustainable Fashion, Sustainability.

1. Introduction

Along with human development, fashion is not merely clothing with its original function, but rather, in the modern context it carries spiritual values that go beyond its mere functional values. However, the fashion industry has major negative impacts on the environment and society. Existing studies show that it pollutes the planet and people in all phases, from raw material production to manufacturing, distribution, as well as end-of-life disposal (Fletcher, 2008; Ninimaki, 2013; Vezzoli, 2000). The fashion industry uses a large amount of natural resources. Taking water resource as an example, it can take 2,700 liters of water to produce the cotton needed to make a single t-shirt (WWF, 2013). Pulse of the Fashion Industry reports that the industry consumes about 79 billion cubic meters per year - enough to fill nearly 32 million Olympic-sized swimming pools - and its water use is set to increase by 50 percent in the next ten years. Furthermore, this is also one of the most polluting industries in the world. In the cotton production, cotton covers nearly 2.5% of the globally cultivated land, yet cotton growers are responsible for 16% of global insecticide release - more than any other single crop. These toxic chemicals not only affect workers but also pollute the ecosystem (EJF, 2007).

Problems do not only exist in the textile and clothing sector. The accessory sector has also been facing challenges in leather tanning, shoes and bags manufacturing, and disposal processes. To date, leather is still one of the main materials used in fashion accessory. However, the leather and tanning industry is a heavy-polluting industry which uses natural resources intensively. In addition to the large amounts of resources (e.g. land, animal feed and water) required to raise animals, significant environmental impacts are associated with tanning and finishing processes, as well as with the energy production and transportation stages (Joseph and Nithya, 2009). In addition, the production of leather from skin is a complex process which uses a variety of toxic chemicals. Thanikaivelan et al. (2007) find that pretanning and tanning processes contribute 80–90% of the total pollution load. This can lead to toxic load in wastewater and poses health hazards, potentially leading to
cancer risk for those in the industry, as well as those who live near the waste stream from tanning factories (Mwinyihija, 2010). In addition, for fashion accessory products, the manufacturing has been and continues to be a noxious process for not only workers but also the ecosystem. Taking the footwear industry as an example, in order to produce a pair of running shoes, over 13kg of carbon emissions are discharged, equivalent to holding a 100watt bulb for a week, according to an MIT-led lifecycle assessment. Nike brand, for instance, sells an average of 120 million pairs of shoes every year (Nike, 2016). These indicate a clear level of direct and indirect impact of the footwear industry on both human and the natural environment, not to mention the disposal phase. Another main sector of fashion accessory is jewelry design, which also has significant environmental effects in the use of rare natural resources such as diamond and gold. The process of exploiting these resources causes significant ecological and environmental change. In the jewelry sector, the use of certificates is common to ensure that materials are sourced from conflict-free areas. Diamonds and gold, for instance, are recognised by Kimberley Process certificate and Golden Rules, in order to ensure the extraction methods are without injurious impacts (Cappellieri, 2012). Therefore, changes in the way products are created are needed in order to minimize the consumption of natural resources and to reduce the impacts on the environment.

In addition to the environmental impacts mentioned above, the fashion accessory sector has a strong socio-economic impact. Beyond a doubt, it is one of the largest industries in the world, able to produce a huge number of commodities, creating jobs for millions of people. However, the downside of the industry is its unsustainable development. This involves the consumerism of modern society and the obsession with catching up with the trend of consumers who are "fashion victims" all over the world. Currently, collections are no longer launched twice a year for the Spring/Summer and Autumn/Winter seasons. Instead some retailers are introducing their new collections monthly, offering new products every week such as Zara and H&M. Furthermore, from raw materials to finished products, almost every stage is carried out in low and middle-income countries. There have been several reasons for moving manufacturing from European countries to other continents such as Asia and Africa since the twentieth century. First of all, low-income countries provide cheap labor for the manufacturing process. Although industrialization has offered many different types of machinery, the fashion industry is still characterised by products made by the hands of workers either directly or indirectly. Second of all, the amount of money famous fashion retailers, mostly from high-income countries, have to invest in buying or renting factories in low and middle-income countries tend to be much lower than it would be in their original countries. Finally, the direct negative effects of the manufacturing process on both the environment and people have also led to the relocation of manufacturing. In bag and shoe factories, workers in certain stages of manufacturing are often listed as workers in hazardous sectors and occupations (Fletcher, 2008; Niniimaki, 2013; Black, 2012; Hethorn and Ulasewicz, 2015).

The above issues belong to the fashion industry and people who work in this sector might be aware and understand the challenges, however, others including consumers and designers may not still be fully informed about the downsides of the industry. Thus, consumers and designers seem to be pursuing consumerism. However, at the same time, in high-income countries there is a revolution taking place in the minds of consumers about "green fashion", "ethical fashion" or "sustainable fashion." As consumers perceive the negative impact on the environment and workers of the fashion industry, especially the fast fashion industry, they fight for fair working conditions in factories, and they speak out against the raising and slaughtering of animals to provide materials for fashion products. These movements are becoming more and more popular in the community. Studies have indicated that customers are often willing to pay more for sustainable fashion products, even if it means having to pay more for it than for a similar product that is not sustainable (Chan et al., 2012; Shen et al., 2012; Reiley, 2015). At the same time, finding brands that are committed to sustainability in the designing, manufacturing and disposing processes is becoming easier, especially in high-income countries. Likewise, courses and disciplines related to sustainability and sustainable fashion in European and North American countries are becoming more popular and accessible (Fletcher, 2002; 2013; Gwilt, 2013; Hethorn and Ulasewicz, 2015).

Based on the above understanding, the need for a shift in the fashion industry (i.e. changing fashion systems towards sustainability, especially the methodologies applied to design, manufacturing and the disposal of fashion products) becomes
imperative. It is assumed that there are many environmental and socio-ethical benefits once accessory fashion brands/companies commit to sustainability. These can range from the changes in their vision, to raising awareness, using guidelines with sustainability criteria, and gaining benefits from efficient production and the use of innovative business models that all can bring direct and effective social and environmental change (Bui et al., 2017).

A number of tools and methods exist for assessing the environmental impact and for reducing the negative impact of fashion products throughout their lifecycle. These include general assessment tools and methods such as Life Cycle Assessment, as well as more specific ones such as the Life-Cycle Design Strategy Wheel; Sustainable Design Cards; Textile Eco-Metrics Tool; Environmental Apparel Design Tool; and Fashionable Bridges (SFB) Ideation Toolkit. Each tool and method has its strengths and weaknesses. They are, however, designed to assist designers, manufacturers and customers in making decisions in the product design and development processes, as well as the use and disposal phases (Hur et al., 2012).

The trend of transformation that is taking place in fashion design is an indispensable trend, and therefore the aim of this paper is to investigate the relationship between fashion and sustainability with a focus on Design for Sustainability (DfS) in fashion accessory. In addition, by evaluating the benefits and limitations of case studies, this study also aims to answer the following research questions: Can DfS be applied effectively to the accessory design process? If so, how can DfS be integrated into the design process?

2. Methods

2.1. Objectives

The overall objective of this study is to analyze case studies of DfS applied to Accessory Design in order to evaluate developments in the relationship between theory and practice. Furthermore, research results provide valuable information for validating and adapting design methodologies once applied to the design, manufacture, and consumption processes, with a focus on Accessory Design.

2.2. Process

This study follows a case study research approach. A case study analysis is conducted and is based on "an embedded single-case design" (Yin, 2003) with two units of analysis: (1) Sustainable accessory product/service and (2) DfS methodologies applied in designing, manufacturing and distribution and disposal processes. Firstly, a research format is designed to facilitate the analysis of case studies, which includes the following two aspects: (1) general information and characteristics of the selected accessories and (2) factors influencing DfS in fashion such as competitive factors, as well as sustainability benefits, barriers and constraints encountered. Based on this format, twelve fashion companies have been selected. These companies/groups have committed to Sustainability to varying extents and have applied DfS in the design, manufacture and/or service processes. The selection is based on the disclosure and transparency of the sustainability implementation that is available in information channels such as sustainability reports, websites and media. The selected case studies focus on three main categories of fashion accessory, namely footwear, bags and jewelry, and can be divided into two areas: one being DfS in fashion for products and those for services. The sustainable approaches taken by the selected companies in each case study are investigated in the following respects:

1. Recycle - design using already reprocessed waste materials, reclaim, re-use waste materials and design with materials that would otherwise be discarded
2. Upcycle - design using reprocessed or waste materials to make a product of equal or higher and not lower quality;
3. Repair and remodel – make an existing item good again or fit for new purpose;
4. Recreate - creatively re-think, customize or re-design an existing design concept;
5. Reduce - design for minimal use of energy, minimize or eliminate waste materials;
6. Use ecological materials - design choices for environmentally benign fibres, fabrics and other materials, seeking to minimize impact;
7. Use mono materials - use of only one material to facilitate recyclability;
8. Harness new technologies - apply technology to achieve reductions in energy, materials or develop more efficient new process;
9. Longer lasting fashion - design with high-quality materials and making, with aesthetic durability creating emotional bonds in addition to function;
10. Multifunctional use - design with more than one use or configuration;
11. Re-thinking design for the entire fashion lifecycle - design concern for use and end-of-life and possible re-use or disassembly;
12. Design for delight - creating new and sustained feel-good relationships with clothes to be valued. (Black, 2008)

For the following case study analysis, data were collected from secondary sources such as scientific papers, websites and internal documents. The sources and information used for the case studies are all publicly available through e.g. company websites and sustainability reports.

3. Results and Discussion

It is designers who make decisions on materials, production methods and the model of consumption, as well as the life cycle of the product or service (SEC, 2009). Therefore, the design phase plays an important role in the life cycle of a product (UNEP, 2004). From the environmental viewpoint, a sustainable product should meet the following general principles:

- Low-impact materials: designing for the use of non-toxic, sustainably-produced or recycled materials which require little or no natural resources (such as energy and water) to transport and process, and whose use does not threaten bio-diversity;
- Resource efficiency: designing manufacturing processes, services and products which consume as little natural resources as possible;
- Quality and durability: creating longer-lasting and better-functioning products that last longer, or age in a manner that does not reduce the value of the product, reducing the impact of producing replacements;
- Reuse, recycling and renewability: designing products that can be reused, recycled or composted after initial use. (SEC, 2009).

According the guideline of Black (2008) mentioned above, designers might be able to improve the use of materials and make the product more environmentally friendly; or to improve the product quality so that it has a long-lasting life. In addition, minimizing the use of energy or irreplaceable resources, avoiding waste also can reduce carbon emissions and harmful impacts on the ecosystem. Table 1 summarizes the case studies collected around the world and is categorized based on the guidelines highlighted in Section 2.2.

<table>
<thead>
<tr>
<th>DfS Typology</th>
<th>Product/Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycle</td>
<td>Ultraboost X Parley Adidas</td>
<td>Adidas collaborated with Parley for the Oceans to eliminate plastic waste in the seas. The project focused on creating a new 3D-printed sneaker concept – Ultraboost X Parley. The product consists of an upper part made from &quot;ocean plastic content&quot; and a 3D-printed midsole made from recycled polyester and fishing nets. This means approximately 11 less plastic bottles in the oceans per pair produced.</td>
</tr>
</tbody>
</table>

Benefits and competitive factors
This collaboration helped Adidas take the role of leadership on sustainability in the...
Foothwear industry. Adidas described this project as follows: “the plan that can end plastic pollution”. These shoes were unveiled the first 3D-printed sneakers made from recycled plastic ocean waste and other recycled materials. Although the process of turning plastic into a usable material is laborious, “it is an on-going challenge, but we achieved the first step. Now we can replace new plastic with recycled marine plastic debris” (Parley) and “Together with Parley we are reinventing the plastic economy. New methods. New materials. New future” (Adidas).

**Barriers and constraints**

The process of turning plastic into a usable material is laborious. Furthermore, the shoes made from recycled plastic ocean waste are being sold at a higher price. They cost approximately 1/3 more than a similar (non-recycled) pair in the same category made by Adidas. This can lead to customers’ consideration before buying a sustainable product and the amount they have to pay for it.

### 2. Upcycle

**Bottletop**

The vision of Bottletop is to create products that combine artisanal production techniques from diverse cultures with elevated design using sustainably sourced and upcycled materials. Most of their bags and accessories are made using the following materials: (1) upcycled aluminium and metal tabs and ring-pull (2) enamel finish (3) Certified Amazon Zero Deforestation leather and (4) East African farmed cotton canvas weaved in Kenya, farmed in East Africa and AZO dye tested.

**Benefits and competitive factors**

There are several environmental and economic benefits of using upcycled materials such as reducing raw material use, energy consumption and carbon emissions (Jeevan, 2012). Aluminum production from raw material consumes a great deal of energy, especially when compared with other materials or recycled aluminium. However, once produced, aluminium can generally be upcycled into the same quality of aluminum as the original products, thus creating something of similar or greater value in its second life.

In addition to the sustainability benefits, such design process also enables the company to improve its corporate social responsibility strategy. Bottletop aims to empower local people to become highly skilled artisans through sustainable design, and to positively impact people and the planet at each product development phase from the raw materials used to the moment it reaches customer.

**Barriers and constraints**

Although upcycled materials are used, it is unclear what happens once the product reaches the hands of the customers and eventually the end of its life. Closing the loop would create more profits and environmental benefits to the company as they would be saving money on the acquisition of upcycled resources. In addition, although Certified Amazon Zero Deforestation leather have lower environmental impact and lower carbon emissions than conventional leather, it does not address any of the negative impacts of leather production (e.g. resource use associated with raising animals, processing and treatment of leather) highlighted in section 1 of this paper.

### 3. Repair and remodel

**Elvis & Kresse**

Elvis & Kresse collects decommissioned fire-hose from across the UK. After scrubbing away the soot and grease from the hose that built up after 25 years of active duty, they use the material to create hand-made accessories such as bags, belts, purses and wallets. They also use other reclaimed materials such as reclaimed military grade parachute silk and racing sail cloth. Their packaging is also reclaimed and includes tea sacks, coffee sacks, sail cloth and parachute silk.

**Benefits and competitive factors**

The benefits to collect and repair materials from no longer wanted products are similar to that of upcycling. This strategy not only saves materials from being discarded by giving them a useful second life, but also saves raw materials and reduces energy consumption which is economically beneficial for the company.

**Barriers and constraints**

Although the design process does extend the lifespan of reclaimed materials by turning them into accessories or packaging and thus giving the materials a second life, it does not explicitly take into consideration the further use of materials post their second life.

### 4. Recreate

**Creative Recreation’s 3 in 1 Boot**

Creative Recreation developed a three-in-one boot design that encompasses three boots: a bootie, a knee-high, and an over-the-knee.
<table>
<thead>
<tr>
<th></th>
<th>Benefits and competitive factors</th>
<th></th>
</tr>
</thead>
</table>
| 5. Reduce Chico Bag | The design of products and accessories that creatively re-think, customize and re-design an existing design concept can help conserve resources. Such design also gives the product multifunctional and dynamically configurable use making them adaptable to the often rapidly changing in needs and preferences of customers.  
**Barriers and constraints:**  
The downside of this particular design is that it is made from snakeskin and suede, and promotes the use of animal flesh and skin for fashion. Since the negative impacts of leather production have already been discussed above, the authors will not elaborate further on this issue.  |
| 6. Use ecological materials Alexandra K |  
Alexandra K promotes animal and environmental friendly fashion by designing and making hand-made vegan bags and accessories using vegan synthetic leather. Consciousness of the environmental problems associated with the leather industry makes the idea of using leather goods less desirable for both designers and consumers, and calls for the replacement of leather with alternative ecological materials that have similar properties but lower environmental impact.  
**Benefits and Competitive factor:**  
The use of artificial leather may be chosen for ethical reasons. This artificial fabric is fast replacing conventional leather in the fashion industry (including footwear and accessories) due to its leather-like finish and similar look and feel to traditional leather (Kinge et al, 2013). The biggest advantage of this design is that it avoids the use of animal products and promotes animal and environmental friendly fashion accessories. It also serves as inspiration demonstrating that alternatives to conventional leather fashion accessories can be designed and produced by using synthetic materials with similar look and feel.  
**Barriers and constraints:**  
The environmental benefits will depend on how the synthetic leather is produced and what materials and processes are involved in the production of the material. No such information is available for Alexandra K designs therefore it is difficult to assess the environmental sustainability of the design.  |
| 7. Use mono materials Crocs | Crocs is a well-known footwear company with casual footwear designs. The Classic Clogs are recognized as a simple and smart design made of EVA (Ethylene-vinyl acetate).  
**Benefits and Competitive factor:**  
Crocs uses a material that makes recycling easier. With a commitment to not using animal-based products, Crocs has large customer base, e.g. supporters of the Peta movement. "Sustainability is a core priority at Crocs," (Scott Crutchfield) and the use of mono materials help Crocs achieve their goal to some extent. In addition, these shoes are |
also highly valued for their durability and functionality.

**Barriers and constraints**

Although Crocs shoes made from mono-materials, the plastics are used for those shoes might be "vaguely recyclable".

| 8. New technologies | Vegea | Vegea is a company that develops innovative technology for producing bio-materials to be used in fashion & design industries. **Benefits and competitive factor**

With their innovative technology which transforms grape marc, one of the by-products of wine making, into high value added bio-material, Vegea is able to create an alternative to the utilization of fossil and non-renewable resources. Bio-materials derived from grape marc have a capability of being modified for the creation of innovative vegetal fabrics due to its high content of multifunctional components. According to Vegea estimates, from the 26 billion liters of wine produced annually worldwide, 7 billion kilograms of grape marc can be derived which can produce 3 billion square meters of Vegea bio-material annually. They also experiment with new technology that enables vineyard pruning waste to be used to produce a yarn that can be woven into innovative textiles. These utilizations of winemaking by-products contribute to environmental sustainability.

**Barriers and constraints**

The development of the materials and the technology is still in progress, and the company is experimenting with variations of the bio-material that have differing weight, thickness, strength, finishing and texture.

| 9. Long lasting fashion | Lian & Mez watches | Lian & Mez watches are hand-made in Germany, taking pride in the country’s fame for its craftsmanship and long-standing reputation of excellent engineering and high-quality standards in the watch industry. **Benefits and Competitive factor**

Swiss Made Movement ensures high durable and long lasting functionality, while materials such as Sapphire Crystal Glass (used for its durability and high scratch mark resistance), Stainless Steel (used for strength and corrosion resistance) and Piñatex (an innovative material used for straps that is made from pineapple leaf fibre) ensure the production of reliable, durable and long lasting watches. Products that last longer will generally have a lower environmental impact. Long-lasting products create less waste and will have less indirect impact due to the need for less frequent replacement than a short-lived version of the same product.

In addition to the long lasting design, Lian & Mez watches also use natural and sustainably produced materials. The Piñatex fibres are the by-product of the pineapple harvest and therefore no extra land, water, fertilizers or pesticides are required to produce them. It is a natural, sustainably produced, cruelty free textile developed for use as a sustainable alternative to both mass-produced leather and polluting synthetic materials. The material does not only have low environmental impacts but it also creates socio-economic benefits by providing additional income for farmers and creating a new industry for pineapple growing countries.

**Barriers and constraints**

Although Piñatex can be regarded as a sustainably produced material, it does not come without environmental cost. The transportation and shipping of the fiber from pineapple producing countries in the tropics to Germany does have environmental impacts (greenhouse gas emissions). Furthermore, the design does not take into consideration what will happen to the watches once they reach their end of life.

| 10. Multifunctional accessories | Hat bag tote – Azumi&David | The Hat Bag Tote is designed to be a multifunctional accessory which can either be worn as a hat or carried as a bag when not used as a hat. **Benefits and competitive factors**

Designing accessories for multifunctional use contribute to environmental sustainability by the conservation of resources. Instead of using materials to produce two separate items, in this case a hat and a bag, the two functions can be combined into once accessory which will save resources and materials.

**Barriers and constraints:**

The downside of this particular multifunctional design is that it is made from sheepskin.
As discussed earlier, the choice of using animal skin as material for accessories raises concerns about animal welfare, ethics as well as environmental sustainability.

<table>
<thead>
<tr>
<th>11. Rethinking design lifecycle</th>
<th>Nike Grind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nike Grind is part of Nike’s ‘Reuse a shoe’ program that aims to eliminate waste and close the product lifecycle loop by collecting and recycling old sports shoes. The recycled materials e.g. rubber and fabric from shoes, as well as surplus manufacturing scraps are used to make performance products, ranging from new footwear and apparel to sports surfaces such as running tracks, courts, gym floors, carpet padding and playgrounds.</td>
<td></td>
</tr>
</tbody>
</table>

**Benefits and competitive factors**

This remanufacturing process not only enables Nike to create more profits but also to improve its public relations. It is a key strategy to demonstrate the long-term commitment of the company to reduce its environmental impacts by closing the loop on the life cycle of old, worn-out and otherwise unusable athletic shoes (Kumar and Malegeant, 2006).

**Barriers and constraints**

Collection of used products can be challenging and it accounts for a significant part of the total costs of any closed-loop supply chain (Fleischmann et al., 2001). In the case of Nike, worn-out shoes can be sent directly to the processing plant, dropped off at any specified Nike locations, or can be given to a non-profit organisation working in collaboration with Nike on the ‘Reuse a Shoe’ program. This arrangement shifts some of the costs onto the customers, making it more difficult and costly for customers to return old sport shoes, and thus this can make the remanufacturing process less efficient than it otherwise could be when all shoes are returned and available for the company to recycle. Furthermore, even though recycling shoes and turning them into performance products give materials a second life, the design process seems to give little attention to the third, fourth etc. life of the materials.

<table>
<thead>
<tr>
<th>12. Design for delight</th>
<th>Brilliant Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brilliant Earth provides fine jewelry from ethical and pure sources and aims to promote a more ethical, transparent, and sustainable jewelry industry. By making jewelry as beautiful as it can be while producing them in an ethical, transparent, and sustainable manner, Brilliant Earth gives customers the opportunity to create new and sustained feel-good relationships with their jewelry.</td>
<td></td>
</tr>
</tbody>
</table>

**Benefits and competitive factors**

To reduce the demand for additional gold mining, the company recycles gold and platinum from secondary sources which are re-refined so they are of the same high quality as newly mined metals. They only use ‘conflict free’ diamond, i.e. only buying from suppliers that source diamonds that originate from specific mine operators who follow internationally recognized labor, trade, and environmental standards. They also offer lab created and recycled diamonds, which are eco-friendly alternatives. Gemstones are sourced in alignment with safe working conditions and environmentally responsible principles, and thus minimising labor, environmental and community concerns associated with coloured gemstone mining.

**Barriers and constraints**

Although the company’s mission is to improve livelihoods, great inequalities still exist. For example, more than one million diamond miners earn less than one dollar a day, while a simple piece of diamond jewelry can easily be sold for $4,000 or even more.

Based on the results of case studies, the analysis shows that fashion accessory designers have adopted sustainable design principles through various design approaches (e.g. recycle, upcycle, re-use, reduce) and offer services for sustainable products that take into account the product life cycle (e.g. recycle, upcycle, re-use, reduce). On the contrary, to design a sustainable product, the use of these methodologies can be challenging due to the characteristics of the accessory design process, as well as the manufacturing and use phase. In the following section, results are interpreted by analysing some illustrative case studies of DfS applied to Accessory Design.

Re-thinking design for the entire fashion lifecycle - design concern for use and end-of-life and possible re-use or disassembly. In fashion design sustainability criteria must be embedded in all stages: design, production and use. In other words, sustainable fashion should take into account the product life cycle, including the stages of design, manufacturing, logistics, retail, use and disposal. However, the product should be able to have more than one life cycle. Niinimaki (2013)
argues that from an environmental standpoint in fashion, a sustainable product can be integrated into the life cycle as follows: the first option is to use the product as the originally designed function; the second option is to redesign after the end of the first life cycle to create a new product; while the third option is to recycle materials. Therefore, a scenario is designed with longer strategic visions, rather than just stopping at the first option. The results from the case study analysis of the Nike group show that the company has taken into account the end-of-life and took measures to collect sport shoes at the end of their lifecycle. Nevertheless, despite the environmental, social and economic benefits of this measure, Nike faces challenges in the implementation of this project. Even though recycling shoes and turning them into performance products give materials a second life, the design process seems to give little attention to the third, fourth etc. life of the materials (see Table 1).

Recycle - design using already reprocessed waste materials. The concept of recycling has become popular for designers who are interested in sustainable development because the material is an important factor in DfS in Fashion. The recycling of materials can be considered in two ways: using recycled materials in a new product and/or design a product in which materials can be recycled at the end of life. Although recycling can save new materials, they need energy for the transformation process to make them recyclable and usable. This is considered as a way of managing waste, but not a way of reducing it (Aakko et al., 2013). In addition, the use of waste materials for recycling receives the social responses because of positive environmental impacts; however, products made from recycled materials tend to have a higher price than products using new materials. In the case of the Ultraboost X Parley, Adidas collaborated with the Parley movement to use waste from the ocean such as plastic bottles and fishing nets for shoemaking. This collaboration helped Adidas take on the role of leadership in sustainability in the footwear industry. Adidas described the project on their website as follows: "the plan that can end plastic pollution". These shoes were launched as the first 3D-printed sneakers made from recycled plastic ocean waste, as well as other recycled materials. However, its price is one third more expensive than a pair of shoes that this brand produces due to the collecting and recycling processes (Table 1).

Upcycle - design using reprocessed or waste materials to make a product of equal or higher, not lower, quality. Following the trend of a design based waste solution, fashion products are upcycled from waste or discarded materials, and thus new products are created with a higher retail value than traditionally recycled goods (Han et al., 2015). In this process, the creativity of fashion designers plays a very important role. They design a new product from those materials and improve their shapes and aesthetics. Bottletop's upcycled bags are a good example of the integration of handcrafting with the reuse of waste and discarded materials, as well as eco-materials. The brand commits to sustainability and designs sustainable luxury bags with four main materials: (1) upcycled aluminium and metal tabs and ring-pull (2) enamel finish (3) Certified Amazon Zero Deforestation leather and (4) East African farmed cotton canvas weaved in Kenya, farmed in East Africa and AZO dye tested.

Use ecological materials - design choices for environmentally benign fibres, fabrics and other materials, seeking to minimize impact. Using ecological materials in the design is an environmentally beneficial approach as it minimizes the use of natural resources, and reduces pollution in the production and disposal processes (Aakko et al., 2013). However, in order to achieve "eco-efficiency" following the theory "cradle to cradle", the philosophy developed by Braunart and McDonough, it needs to be adapted to suit the design methodologies. A product that uses eco-friendly materials can easily be recycled or disintegrated if it contains one material, rather than two materials. When both biological and industrial materials are used and mixed in a product, it becomes harder to separate materials, recycle them or disintegrate them at the end of life. Consequently, it is no doubt that a product may not necessarily be environmental friendly even if the material used in the product is (Aakko et al., 2013).

Use mono materials - use of only one material to facilitate recyclability. A product that is composed of a single type of material or a product with components that each are made of a single type of material and that can be split apart. Using only one material makes it easy to re-use or recycle at the end of the product life cycle (Hasling et al., 2017). In fashion, it is
not uncommon, but this principle is largely applied in garment products using only one type of textiles. Typically, dresses, t-shirts or other clothing items are made from 100% polyester or cotton, and often even the thread or button are made of the same material. Furthermore, in jewelry design, using mono-materials is also popular such as metal, wood or stone materials. Other fashion accessory items, however, are designed with complex structures due to functional requirements and sometimes, due to the traditional method of manufacturing. Shoes and bags, as an example, are made up of more than one component with different materials.

**Multifunctional products - design with more than one use or configuration.** The product is designed to fit multiple functions for one or more users by a transformation of function, transformation of function into context or/and transformation to body type. The advantage of this kind of product is that it minimizes the use of resources by optimizing the usability of the product (Fletcher and Grose, 2012). However, for a product to meet multiple functions at the same time, designers face the threat of having low product functionality in general. The Hat Bag Tote is designed to be a multifunctional accessory which can either be worn as a hat or carried as a bag when not used as a hat. Although this is a smart design, it is hard to say that it suits with a casual or event costume as can be seen from a function and/or purpose perspective.

The 12 case studies demonstrate that it is possible to use DfS methodologies in the fashion accessory design process, and designers do apply some of these in order to design more sustainable fashion accessories. However, from the analysis of the case studies it becomes evident that only one or two different strategies are applied at a time, indicating that the holistic application of more than one or two DfS methodologies is not widespread and common practice to this date. Taking Lian & Mez watches as an example, we can see that two DfS methodologies are applied (long lasting fashion and the use of ecological materials), however other principles (e.g. upcycling, recycling) could also be incorporated in the design process to further improve the sustainability of the watches.

### 4. Conclusions

The fashion industry has become one of the most polluting industries in the world, with major negative impacts on both the environment and society. In this paper, we argued that a trend of transformation in fashion design is essential in order to minimize the negative impact of the fashion industry. Designers can play a major role in this transition and can address some of the major problems created by the fast fashion industry by applying Design for Sustainability (DfS) criteria.

The aim of this paper was to investigate the relationship between fashion and sustainability, with a focus on Design for Sustainability in fashion accessory. This research qualitatively assessed the potential benefits and constraints of the application of DfS in Fashion Accessory Design by analysing 12 illustrative case studies of DfS applied to Accessory Design. The results of the case studies demonstrated that DfS can be effectively applied in the accessory design process to create more sustainable products and services. Nevertheless, further research focusing on quantitative evaluation could be beneficial in quantifying the magnitude of benefits of the application of DfS methodologies in making fashion accessory production more sustainable. Obviously, the potential benefits must be verified on a case-by-case basis to meet the expectations of the designers, manufacturers and the needs of customers. In some cases, the achievement of sustainability targets depends on a number of factors, including customer perceptions and product usage guidelines towards sustainability.

Based on the results of this study, we argued that despite the benefits of the application of DfS, there is scope for improvement in using DfS methodologies in the accessory design processes. The case studies revealed that only one or two DfS methodologies are generally integrated into a particular accessory design process, and there is not a holistic application of multiple DfS strategies to various processes within accessory design. Thus, all the potential sustainability benefits of the application of DfS are not fully harnessed in accessory design yet. Whether this is due to the lack of awareness of the DfS criteria and its application in the fashion accessory design process, or due to complexity involved in the application of more than one criteria is unclear. However, once the reasons are known, different strategies can be implemented to promote the holistic application of DfS criteria in the design process in order to create fashion accessories with less negative impacts.
References


Kumar, S., Malegeant, P., 2006. Strategic alliance in a closed-loop supply chain, a case of manufacturer and eco-non-profit organization. Technovation, 26, 1127-1135.


