To what extent is it possible for a denim company or denim department within a company to implement a fully sustainable denim development process?

Research Report

Emily Kenny-Troughton
500668689

International Fashion & Management

Ligia Hera & Jacqui Haker

13/06/2016
Disclaimer:

1. This report, as part of the graduation project aimed at attaining the BA title from the Amsterdam University of Applied Sciences, has been written and/or compiled solely by me.

2. This project report (or any amended form of it) has never before been submitted by me or anyone else in the framework of a learning assignment aimed at the attainment of a certificate or degree, within the AMFI programme or elsewhere.

3. The work that was necessary for the realisation of this project was performed entirely by me. All the data that have been collected are original.

4. All quotes from other sources are recognisable in the report by quotation marks and the sources of all my information have specifically been indicated.

Date: 13/06/16

Place: 

Name: Emily Kenny-Troughton

Signature
# STRUCTURE

Executive Summary ................................................................. 3

Chapter 1 – Introduction ............................................................. 4

Chapter 2 - Definitions required by the research .......................... 7

Chapter 3 - The environmental and ethical impact of facilities involved in denim development, and sustainable ways to combat these ...... 9

Chapter 4 - The traditional development processes a denim product goes through and new, sustainable alternatives. ...................... 11

Chapter 5 - The feasibility of implementing a fully sustainable denim development process for a denim company or department .... 25

Chapter 6 – Conclusion ................................................................. 28

Chapter 7 – Product ................................................................. 28

References ................................................................. 30
EXECUTIVE SUMMARY

Sustainability is a key factor in the current global zeitgeist of mental, physical and environmental wellbeing (Forbes, 2015). Within the denim industry there are many “green” alternatives to current fabric choices and production processes but these are often not combined due to lack of communication between parts of the supply chain and the brands (Veenhoff, 2016). This disconnect opens up an opportunity to research the feasibility of a fully sustainable denim development process, and produce a tool that helps to fill this gap. In order to assess the possibility of creating a sustainable denim development process, I posed the question ‘To what extent is it possible for a denim company or department to implement a fully sustainable denim development process?’.

The research question required a definition for the term ‘fully sustainable’, which was found through defining the term ‘sustainable’ first. Within the context of this research the term ‘sustainable’ is defined as ‘having either a neutral or positive environmental and/or ethical impact’. This led to ‘fully sustainable’ being defined as ‘a product or process that has a completely neutral or positive environmental and ethical impact’. Another required definition was that of ‘denim development process’ which, with regards to this research, covers the impact of fabric choice, washing choice, trims choice and development related facilities. The main environmental issues through all categories were the high water use and related chemical use, which then polluted the local areas. In terms of ethical issues the main concern was that of worker safety in all facilities in the development process, from farm to factory.

In terms of the environmental and ethical impact of development related facilities, it has shown to be very difficult to be classed as ‘fully sustainable’. While many facilities have shown great enthusiasm for taking sustainable measures, (Canatiba, Tonello), and shown that is feasible to implement a ‘more sustainable’ approach, they simply have a neutral impact, and not necessarily a positive or beneficial one. It has been proved that it is possible and feasible, (if expensive), to implement a fully sustainable approach to fibre choice and wash choice as all areas have options that have both a positive environmental and ethical impact. Given the current situation it is not possible to work with a fully sustainable fabric or set of trims due to the current dyeing practices and widespread use of metal trims. These require large amounts of non-renewable resources and are therefore categorised as ‘less sustainable’. However, there are more sustainable options available which raises the trims approach to a ‘more sustainable’ level overall.

Overall it is possible and feasible for a denim company or department to implement a fully sustainable denim development process to a large extent, although not all resources available to them are currently up to the necessary standards. The outcome of this research will be a product that will take the form of an online tool that fills the need for a central source of information on sustainable choices in the denim development process. It is a website that has both an educational side that is accessible to all viewers, and a retail side which allows those with access a chance to create and develop their own sustainable denim development.
Chapter 1 – Introduction

1.1. Background paper idea

Through researching articles for the Inspiration Book project in my first few weeks as an AMFI student, I uncovered an interest in the sustainability issues faced by the fashion industry as a whole, which has progressed over the years to a focus on the sustainability issues in the denim industry. As the issue of sustainability is still a very relevant one, and my previous experience with the denim industry has been in a product development and production capacity, this led to the final research question.

1.2. Opportunity statement / problem statement

Within the denim industry there are many “green” alternatives to current fabric choices and development processes but these are often not combined due to lack of communication between parts of the supply chain and the brands (Veenhoff, 2016). This disconnect opens up an opportunity to research the feasibility of a fully sustainable denim development process, and produce a tool that helps to fill this gap.

1.3. Relevance of the research report

Sustainability is a key factor in the current global zeitgeist of mental, physical and environmental wellbeing (Forbes, 2015). The concept has spread through all product categories and is steadily becoming a regular feature through special collections, e.g. H&M’s ‘Conscious Exclusive’ collection, or through a brand’s entire collection, e.g. Nudie Jeans only using organic cotton (Nudie Jeans, 2016).

Sustainability and denim are two areas of fashion that are currently going through revolutionary stages in their relationship with the industry, making this topic incredibly relevant for denim companies or departments.

The sustainable angle in this research is mainly fuelled by the lack of communication along the denim supply chain, but is also inspired by the little-to-no responsibility or accountability held by the facilities used by brands for the effect they have on the garments through a sustainable or ethical standing. After the Rana Plaza catastrophe in 2013, many end consumers were shocked to find out the circumstances in which their clothes have been made, and as a response scores of brands pledged to improve working conditions for their employees. 3 years on and many brands haven’t followed
through on their promises (International Labour Rights Forum, 2016), so it is of high importance that these issues are not forgotten.

A large part of the sustainable solutions currently offered focus on the fibres used to create the garments, and the ethical and environmental impact that they have. Aside from the petroleum based obvious "bad guys" like polyester, cotton is one of the least sustainable fibres currently in use by the clothing industry. Issues with the fibre range from enormous water usage to the controversy of GMO crops, exploitation of farmers to the widespread use of harmful chemicals. Around 20 million tonnes (US) (18,14 billion kg) of cotton are grown every year (wwf.panda.org, 2016), and these fibres are present in over 50% of all clothing and other textiles (cottoninc.com, 2016). An example of how inefficient growing cotton is, it takes around 1514 litres of water for a simple cotton t-shirt (including all processes) and around a staggering 6814 litres of water (TreeHugger.com, 2016) to fully process a pair of jeans. The amount of cotton needed for 1 t-shirt and 1 pair of jeans is 1kg (wwf.panda.org, 2016), and just over 1 billion pairs of jeans are sold annually on a global scale ( statisticbrain.com, 2016), which gives a rough total of around 1 billion kilos of cotton being affected by the denim industry a year. This shows that steps taken to reduce denims impact can have large-scale consequences.

This research report is therefore very relevant for denim companies, departments and professionals as it highlights and tackles both environmental and ethical issues within the context of denim development processes.

1.4. Goals

This project will produce a research report and process book, and as a final product an online tool that is a centre of information for denim companies or denim departments of different sizes. This will also have the function of allowing them to create and develop a more, or fully, sustainable denim development process through showcasing existing products currently offered by a range of denim mills, laundries and trims manufacturers.

1.5. Research question and sub-questions

This research aims to uncover to what extent a denim product can be developed in a sustainable manner, which has lead to the research question of "To what extent is it possible for a denim company or department to implement a fully sustainable denim development process?". In order to have a well rounded answer this, I will use the
following subsidiary questions: “What definitions are required by this research?”, “What environmental or ethical impact can facilities involved in denim development have?”, “What traditional development processes does a denim product go through, and are there new, ethical/sustainable alternatives?” and “Is it feasible for a denim company or department to implement a fully sustainable denim development process?”. 

1.6. Methodology

The methodology will mainly consist of primary research such as interviews with denim professionals, and secondary research. To answer “What definitions are required by this research?” I will refer to existing definitions by academics, retailers, brands and consumers, as well as considering the relevance for this particular topic. To answer “What environmental or ethical impact can facilities involved in denim development have?” I will primarily do interviews with professionals in various product segments to gain a general view through visits, email and visiting fairs such as Amsterdam Denim Days and Kingpins. In order to answer “What traditional processes does a denim product go through and are there new, sustainable alternatives?” I will interview denim professionals and consumers to understand their view on the issues, as well as doing other primary research. The majority of the alternative solutions will be found through primary and secondary research. The final question, “Is it feasible to implement a fully sustainable denim development process?” will be answered through researching precedent, analysing the costs of the product and opinions of various denim professionals.

1.7. Organization of the report

The report will start with an executive summary and introduction (Chapter 1), followed by highlighting and defining key terms related to the research (Chapter 2). This will give the reader a basic understanding of the topic and the terms used often in the report. Each chapter will have a small conclusion to help solidify the findings for the reader. Chapter 3 will uncover the sustainable and ethical issues that can be presented at or by facilities related to the denim development process, and give examples on what facilities are currently doing to combat them. This will then lead to Chapter 4, which discusses the traditional denim development processes, the current alternatives and questions how sustainable these alternatives are. In order for this report to be relevant for denim companies and departments, Chapter 5 outlines the feasibility of creating a fully sustainable denim development process. Finally Chapter 6 concludes
report and gives an outline on the final product and how it can be used.

1.8. Limitations of the research

Due to this report focusing on both what needs to be changed and also the feasibility, there are some unavoidable limitations to this research. As much of the research on what the issues are and how to combat these is freely available online and in print there are not many problems. However, it is important to review sources of information carefully, e.g. information about a product from the company that creates it is likely to have a positive bias. The research on the feasibility has more drawbacks, such as the difficulty in measuring amounts of energy or water saved and the exact costs of subjective tasks like washing denim. This research is by no means a definitive report on the feasibility of a fully sustainable denim development process, and the conclusions drawn have been based on the information that has been available.

Chapter 2 - Definitions required by the research

There are many definitions required in this research such as what ‘denim’ is classed as, what constitutes ‘fully sustainable’ and what is the scope of ‘development processes’. Below are the definitions written for this research that not only consider academic input, but also the relevance to the question and the opinions of industry professionals.

2.1. Definition of Denim

Denim, the modern version of the original name ‘Serge de Nimes’, was accidentally developed by the Andre family in Nimes, France in the 1500’s (denverfabrics.com, 2016). The fabric was then popularised by Levi Strauss and Jacob Davis in 1873 (historyofjeans.com, 2016). The combination of the fabric provided by Strauss and the patent on the rivet technology co-owned by both men led to the start of jeans as we know them today. There are 5 main aspects often focused on when defining denim: the fact that it is classed as ‘hard-wearing’, the weaving structure, the fibre, the potential use of the fabric and the colouring. For the purpose of this research denim will be defined as a hardwearing, twill structured fabric with coloured warp yarns and white (natural or bleached) weft yarns. The fibre of the denim will not be addressed in this definition to not limit the fibre options later in the research.
2.2 Definition of the term ‘fully sustainable’

For this research the term ‘sustainable’ will comprise of both environmental and ethical elements in order to give a deeper and more well rounded understanding of the impact of the denim industry. Regarding environmental impact the term ‘environmentally friendly’ in terms of this research will cover the effect each area has on nature, e.g. the effect on flora and fauna, the contribution to climate change. For each section of the development process the environmental impact will be analysed using varying measures, e.g. water use, chemical use, energy efficiency. This links in with the opinion of Dries van Noten who believes that the sustainability of a garment is based on the entire lifetime of the garment, for example, not only the environmental friendliness of the fabric that arrives at a factory, but also the impact it had travelling there (Friedman, 2010).

With regards to the ethical impact, the term ‘ethical’ in terms of this research will cover the effect each area has on humans and animals e.g. humane practices, living wages, enforced safety protocols. This was inspired by the documentary released in 2015, ‘The True Cost’, by Andrew Morgan, which was an eye opening look into the reality of the impact the fashion industry as a whole has on the world.

Considering the above definitions, ‘sustainable’ within the context of this research is defined as having either a neutral or positive environmental and/or ethical impact. For the purposes of this research products and processes will be categorised as ‘unsustainable’, ‘less sustainable’, ‘more sustainable’ or ‘fully sustainable’. ‘Unsustainable’ means that the product or process has a completely negative environmental and ethical impact, while ‘less sustainable’ means either that the product or process has a completely negative environmental or ethical impact or that the product or process has a mostly negative environmental and ethical impact. ‘More sustainable’ is defined as the product or process has a completely neutral positive environmental or ethical impact or that the product or process has a mostly neutral or positive environmental and ethical impact. ‘Fully sustainable’ is defined as the product or process that has a completely neutral or positive environmental and ethical impact.

2.3 Definition of ‘denim development process’

As the research question deals with only the development processes of denim, it is necessary to outline what sections will be covered by this research. As a general definition with regards to this research, ‘development processes’ concerns fabric choices, trims choices and washes. Fabric choice has been moved from a traditionally design
decision to a development decision in order to more clearly explain
its effects in combination with the washing processes. The fabric
choice sub section will cover the impact of fibre choice, thread
development, dyeing and weaving. Development will also cover the
impact of the facilities associated with denim development on the
sustainability of a product. In conclusion the term ‘denim
development process(es)’ with regards to this research will cover
fabric choice, washing choice, trims choice and facilities impact.

Chapter 3 - The environmental and ethical impact of
facilities involved in denim development, and sustainable
ways to combat these

The fact that facilities used in the development of denim can have a
real impact on the sustainability of the products is something that is
slowly being understood and valued by the industry. It has been
known for many years that the fashion industry has an overall negative
effect on the environment and the workers e.g. Life magazine
exposed Nike using child labour in 1996 and Greenpeace exposed
the pollution caused partly by the denim industry in Xintang, China in
2009, but recently these issues have started to resonate with the end
consumer. A combination of the on-going zeitgeist of health and
wellness (Forbes, 2015), public coverage of catastrophes like Rana
Plaza in 2013 and documentaries like The True Cost in 2015 have all
contributed to a larger push towards an environmental and ethical
approach to fashion. The main sustainability issues that face denim
mills, laundries and production facilities, have an environmental side
as well as an ethical side. In terms of environmental impact the
apparel industry is responsible for 10% of global carbon emissions,
(Conca, 2015) and is the second most polluting industry in the world
(Fisher, 2015). The denim industry specifically is responsible for
producing 33.4 billion kilograms of carbon dioxide
(www.levistrauss.com, 2016) and using around 8.4 trillion litres of
water a year (Veenhoff, 2016). From an ethical perspective, Asian
countries are responsible for 70% of global denim textile production
(Textile Intelligence, 2012), yet 2/3 of them have been deemed
extreme risk countries with regards to labour rights and protection
(made-by.org, 2013). 1,143 garment and textile workers have died
and 3,631 have been injured in Bangladesh alone since December
2012 due to poor or unenforced safety regulations
(solidaritycentre.org, 2015).

Although these issues are difficult to completely be rid of, there are
measures available that can combat them. With regards to
environmental issues it is possible for denim facilities to save water
through fixing leaking pipes, reusing cooling water for dyeing
processes and developing dyeing procedures that require less water. The Natural Resources Defence Council (NDRC) estimates that the average cost of fixing all leaking pipes in one facility is around 0.01€ per ton of fabric and using cooling water for dyeing processes is between 0.80€ - 2.57€ per ton. These measures combined would save between 8.5-15.5% of all water used, and the payback period would only be a maximum of 3 months. Many denim mills including Candiani Denim S.p.a. and Canatiba Denim Industry are working the practice of developing a dyeing process that requires less water. Canatiba has developed a dyeing process that requires 90% less water using a recyclable chemical accelerant, and recycles up to 30% of the total water used, bringing their water savings up to 93% (Covolan, 2016). Although it was not possible to get a cost estimate of this process, it can be considered a feasible alternative for larger denim mills as Canatiba has already been running the process for 3 years. Another way to reduce environmental impact is to reduce energy use, or use renewable sources of energy. The NDRC calculates that by managing steam and recovering and reusing heat from drying operations a facility can save up to 25% of the total energy used. Steam management is a free option that shows immediate benefits, while recovering and reusing heat costs 2.68€-3.95€ per ton of fabric and has a payback period 2.5-8.4 months. Tony Tonnaer, CEO of Kings of Indigo explained that being environmentally friendly is a core element of the denim brand. They currently receive all of the energy needed for their headquarters from solar panels, which has reduced their energy bill by 100% (Tonnaer, 2016). Felipe Covolan of Canatiba also makes use of renewable energy, but scales it up to cover all of their operations, including the mills that produce around 10 million metres of fabric per month (Covolan, 2016). As both of these companies have been working with this system for 2 and 3 years respectively, using a renewable source of energy can be seen as a viable and feasible option for companies or facilities of any size.

Denim facilities, companies and departments can also establish ethical practices by using various methods such as joining an ethically focused foundation or organisation or collaborating to improve conditions for workers. There are many types of organisations and certifications that a denim company or department can join, meaning that there are options for most sizes. For example Made-By, the Business Social Compliance Initiative (BSCI), the Ethical Trading Initiative (ETI) and the Fair Labour Association (FLA) all offer memberships to companies with the aim of developing strategies to improve working conditions and treatment of workers employed by the company. The Fair Wear Foundation offers it members a database of ethically and safety approved facilities, and works with its members to locate and assess new ones. These benefits all have a price tag
however as the organisations require payment in exchange for a membership, most often based upon the yearly earnings of the company. The ETI, for example, states that a company wanting to become a member must have an annual turnover of £1,000,000. This then ensures that they have the resources to be an effective member (www.ethicaltrade.org, 2016). Although this figure is quite high, some organisations like the Fair Wear Foundation have programmes specifically for smaller companies or start ups that require a lower turnover and therefore a lower fee.

Another way for denim companies and departments to combat ethical issues within the industry is to develop long-term relationships with their suppliers and collaborate with them to improve conditions. An example of this would be G-Star RAWs work through the GSRD foundation. Since 2007 they have promoted education and entrepreneurship in the communities where G-Star manufactures its products (www.gsrd.com, 2016). By not only offering opportunities to workers, but also to the workers families, they have created a long-term, positive ethical impact in a viable and sustainable way.

Overall facilities involved in denim development have a big impact on the sustainability of the end product, and it is possible to implement environmental and ethical initiatives within each part of the chain. At this point it is highly unlikely to run a fully sustainable facility due to the costs involved. However by implementing a combination of the environmentally and ethically friendly options explained above many companies could become more sustainable.

Chapter 4 - The traditional development processes a denim product goes through and new, sustainable alternatives

A denim product goes through many of the same stages as a regular garment as can be seen in fig.1, but has its own unique step of washing in which the garment is often partially destroyed to achieve the correct look and feel. This chapter will examine the traditional choices made, and offer more sustainable alternatives where possible.

Denim Development Processes

```
Fabric Choices | Wash Choices | Trims Choices
| Fibres | Buttons & Rivets |
Dyeing | Zippers |
| Leather Patches |
```

Fig. 1 Flow Chart of Denim Development Processes
Fabric Choice

Fibre Choice
Traditional denim uses 100% cotton fibres, and although modern denim uses around 2% elastane to add stretch even to basic jeans (Luiken, 2016), this is still regarded as a fully cotton product due to the low percentage. The conventional process of growing a cotton crop and processing it into thread is one of the most environmentally and ethically unfriendly practices due to its need for high levels of water, pesticides and herbicides during growth, as well as the ethical impacts on farmers due to exposure to harmful chemicals, a monopoly on genetically modified (GMO) seeds (The True Cost, 2015) and a low buying price for the crop itself (prices as of February 2016 were around €0.50 per kg) (Russell, 2016). Sustainable and ethical alternatives to conventionally grown cotton do currently exist, however not all of them can be considered fully sustainable.

These alternatives include, but are not limited to, recycled cotton, in-conversion cotton, organic cotton, organic flax, bamboo fibre, BCI cotton, hemp and nettle fibres, Tencel, Modal and recycled polyester.

Recycled Cotton can come from two main sources, either offcuts and waste from the production facilities or previously worn garments (post consumer recycled or PCR denim). The process of recycling cotton involves shredding the fabric back up into fibre-sized pieces and remaking the yarns. The main issue with this process is that it produces fibres that are shorter than that of the original cotton, making the resulting fabric feel itchier and less comfortable. Unfortunately is not a viable option to make denim out of 100% recycled cotton as the shortened fibres lead to loss of structural integrity in the threads. This means that if a denim product were to be made out of this fabric, it would rip, tear or completely disintegrate relatively easily due to the fibres falling out of the threads, especially if it was a washed garment. Recycling can only be done a finite amount of times before the fibres are too short. However using one kilo of recycled fibres saves 3.25kg of carbon dioxide equivalents, 47MJ of energy and 7,000 litres of water (Paul, 2015). Therefore recycled cotton can be considered a more sustainable option due to its neutral ethical, and positive environmental impact.

In Conversion Cotton is the next option as it is seen as the stepping-stone between conventionally grown and organic cotton. Essentially it is the cotton grown on land that is being transitioned from regular use to an organic practice. This means that it is a more sustainable option compared to conventionally grown cotton as although the soil that
the plants grow in may still have residue in it, the farmers have ceased using pesticides and fertilisers. As it has a neutral ethical effect and a reduced environmental impact, In Conversion Cotton can be seen as a more sustainable option.

Organic Cotton is also a more sustainable option as although it requires the same amount of water and energy as conventionally grown cotton, there are no harmful or toxic chemicals (e.g. chemical pesticides) used in the cultivation of the crop. Organic cotton is already a very widely used ‘sustainable’ alternative in denim and can be seen as a more sustainable crop due to its significantly reduced environmental and ethical impact.

Organic Flax is a good alternative as the fibre is relatively fast growing (it can be harvested after around 100 days) and requires very little water or fertilisers, but needs a lot of pesticides. Currently 2/3 of flax is grown in a belt across Northern France up to the Netherlands, but is then processed and woven into fabrics in China, increasing its carbon footprint. Due to the fabric wrinkling easily and losing shape quickly, flax is often blended with other fibres, which results in an unsustainable fabric. This is due to it being very hard to recycle fabric in which the fibres have been blended within a yarn. An option to reduce the impact of this could be to blend it with recycled cotton, although this will not dramatically reduce the wrinkling issue. As long as the pesticides used are organic, Organic Flax can be considered a more sustainable option as it has a mostly positive environmental and ethical impact.

Bamboo as a the plant needs only one third of the water necessary to grow cotton, does not need pesticides and requires less dye than cotton to achieve the same colour intensity. It also produces 60 metric tonnes per hectare compared to cottons 1 tonne (Giels, 2002) (indexmundi.com, 2016). The way bamboo grows is also environmentally friendly as the root systems of bamboo are thickly clumped balls, which keep the soil together. The debris that falls from the plant is also good because it fertilizes the ground at the base of the plant, and stops the ground becoming overused. However it is important to note two that there are two key points to consider when looking at bamboo fabric. The first is that the fabric itself is actually made from bamboo and it is not bamboo viscose, or bamboo rayon. These fabrics are incredibly harmful for the environment and the people in the surrounding areas due to the need for many harmful chemicals such as lye, carbon disulphide and strong acids that are often not properly disposed of after use. The second is that the fabric has come from land that was not intended for crops, and not from felled forest. As the bamboo business becomes more lucrative, it
becomes more of a problem that farmers are choosing bamboo crops over edible crops and therefore leading to food shortages, and cutting down forests, destroying local wildlife in the process, to make more room for the bamboo. If the bamboo fibre is responsibly sourced and not turned into rayon or viscose, bamboo can be seen as a more sustainable alternative due to its positive environmental, and neutral ethical, impact.

The Better Cotton Initiative (BCI) is one that promotes the growth of cotton with a focus on improving the environmental, economic and social aspects that surround the fibre. BCI Cotton sells to many companies, but it is very rare to find a 100% BCI cotton fabric. As it is such a sustainable alternative to conventionally grown cotton, (with the added bonus of having a marketing angle to it to help the consumer understand), the crops are split between many different companies. Therefore it is commonly mixed with either recycled or conventionally grown cotton, thereby still retaining a 100% cotton label, but reducing the sustainability of the fabric (in the case of adding conventionally grown cotton). BCI Cotton is considered a fully sustainable fibre as it has both a positive environmental and ethical impact.

Conventional Hemp is very different from cotton, as the plant requires little to no pesticides, fungicides or herbicides as it grows so fast it leaves all other weeds in the shade. In order to make threads from hemp, it is necessary to use the bast fibres that are found in the stalk of the plant. This process does not require any chemicals at all, only using the enzymes naturally found in the plant itself meaning that it does little to no harm to the environment, workers or end users of the product. This is essentially the same process as turning nettles into fabric, an idea promoted by G-Star Raw through their ‘Nettle Jeans’ that were introduced in 2008 as part of their sustainable denim options. Conventional Hemp can be seen as a more sustainable fibre option due to its completely neutral impact in both an environmental and ethical sense. It is not regarded as fully sustainable as although it causes no harm, it also does not have a positive impact.

Tencel is a name given to the man made lyocell thread produced by Lenzing. A step forward from viscose, Tencel is a cellulosic fibre made from tree pulp in a closed loop process that has been given the European Award for the Environment from the European Union (Lenzing, 2016). Tencel is an ideal candidate for denim as it has a high durability and resistance to chemicals that proves useful due to current weaving and laundry processes (Kininmonth, 2016). Tencel can be considered a more sustainable fibre as it has a neutral, not positive, environmental and ethical impact.
Modal is the modal thread offered by Lenzing, and is produced in a completely closed loop process. Similar to Tencel in that it is produced from wood pulp (beech), Modal is a softer, bulkier version. An added bonus is that Lenzing grows all of the beech trees necessary for its production on the same site as it produces the Modal thread, minimising transport and ensuring that the trees are grown and logged in an environmentally friendly manner (Lenzing, 2016). This also means that local wildlife is considered and preserved as the company has more direct responsibility in this matter than many other companies. Unfortunately Modal is not used as a single fibre in jeans as it is incredibly soft and bulky, and has a lower durability and resistance to chemicals than Tencel, therefore never giving the desired appearance or feel of a denim. It is often blended with cotton or other fibres and incorporated into brands stretch denim or “leisure” denim, to give a comfier feel to the garment (Kininmonth, 2016). Modal can be considered a more sustainable fibre as, like Tencel, it only has a neutral, not positive, environmental and ethical impact.

Recycled polyester (PET) is a fibre that has been brought to consumer’s attention by brands like G-Star Raw and their “Raw for the Oceans” campaign in collaboration with Pharrell Williams. Polyester can be recycled in two ways: mechanically and chemically. Chemically recycled PET also requires less energy to make than virgin PET, and is recycling a durable and already existing fibre/filament. To create chemically recycled polyester the existing material is broken down on a molecular level and re-attached together to make a yarn as strong as the original. However this practice is currently very rare due to it being uneconomic with current processes. Mechanically recycled PET is the better of the two, as it requires less energy to make than virgin PET, and is recycling a durable and already existing fibre/filament. To create mechanically recycled PET the existing material is melted down and reshaped, therefore does not require the use of any chemicals. However this process can only be performed a few times before the molecular structure of the PET is broken beyond repair. This is the process currently used by Bionic Yarn, the thread manufacturer working with G-Star Raw (bionicyarn.com, 2016). Mechanically recycled PET is a fully sustainable fibre (as long as the energy used to create it is renewable) as it has a positive environmental and ethical impact by reusing plastic waste, preventing it from ending up in landfill or the oceans.

Nowadays threads and fabrics aren’t often made up of a single fibre or filaments, preferring instead to blend natural and synthetic together to create a garment with varying properties. This creates an
issue for companies that would like to recycle their garments, as current methods of recycling make it very difficult to process a garment that has been made from blended fibres. As a general rule, most blended fabrics are considered less sustainable due to its short life span, however like many rules, there are exceptions. For example a blend of various cottons (recycled, virgin, in conversion etc.) would be acceptable as it is still the same fibre. Another exception is that a fabric can be recycled if it is made of 95% or more cotton fibre, meaning that there can be up to 5% of other fibres present (Veenhoff, 2016).

For this research, fabric blends of synthetic and natural or multiple synthetic yarns are considered less sustainable due to their negative environmental impact (cannot recycle or biodegrade). Fabric blends of multiple natural fibres are considered more sustainable as these can often be downcycled, elongating the garment’s lifespan and having a positive environmental impact. Fabric blends of 95%+ cotton or mechanically recycled PET are considered fully sustainable as these can be recycled multiple times into similar level products before being downcycled. This provides a long life span and a positive environmental impact as it reduces the need for virgin production of these resources.

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled Cotton</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>In Conversion Cotton</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>Organic Cotton</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>Organic Flax</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>Bamboo</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>BCI Cotton</td>
<td>Fully Sustainable</td>
</tr>
<tr>
<td>Conventionally Grown Hemp</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>Tencel</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>Modal</td>
<td>More Sustainable</td>
</tr>
<tr>
<td>Recycled Polyester</td>
<td>Fully Sustainable</td>
</tr>
<tr>
<td></td>
<td>(mechanically recycled)</td>
</tr>
</tbody>
</table>

Fig, 2 Summary of fibre findings

To conclude, there are fibre options for fully sustainable alternatives to conventionally grown cotton, and many are already being implemented by various brands. The next step for sustainable fibre use is to create recyclable blends of fully sustainable fibres, which would be a step forward from the current situation of blending them with unsustainable fibres, e.g. conventionally grown cotton.
Fibre

<table>
<thead>
<tr>
<th>Key Sustainable Issues</th>
<th>Water use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use of pesticides</td>
</tr>
<tr>
<td></td>
<td>Recyclability</td>
</tr>
<tr>
<td>Key Ethical Issues</td>
<td>Land use</td>
</tr>
<tr>
<td></td>
<td>Health issues from use of pesticides</td>
</tr>
</tbody>
</table>

Fig. 3 Assessment of key sustainable and ethical issues affecting fibre choice

Dyeing

In traditional denim the warp yarn is dyed with blue indigo, while the weft yarn remains the natural creamy colour of cotton or is bleached white. There are two key areas to consider when analysing the sustainability of dyeing in denim development: the dyestuff itself and the dyeing process.

The original dyestuff for denim was natural indigo or *indigofera tinctoria*, a shrub that is indigenous to large parts of Asia and Africa. The downside of the boom of the denim industry was that it became impossible to grow enough natural indigo to cater to demand. As the *indigofera* plant does not have any other uses apart from making indigo dye, it has to be grown instead of, for example, food crops. There are already many countries where food is scarce enough, without taking over existing agricultural land to grow a dye crop. A positive note about the natural indigo is that the fermentation process required to extract the necessary elements for the dye is 100% natural and only uses ash, water and lime. The only by-product from this process is wastewater, which can then be used as a natural fertiliser (McGinn, 2013). It is a safe and sustainable process, although not on a large scale. On top of this the plant has an annual, or often perennial cycle which means that there is a long wait in between harvests, and the indigo dye is not actually present in the leaves themselves therefore needing an extra process to extract it. In addition to this, 21,336kg of leaves only amounts to 40kg of dye (wildcolours.co.uk, 2016), therefore rendering natural indigo as a fully sustainable, yet relatively inefficient, source of dye.

Synthetic indigo on the other hand has many harmful by-products from its production, and although is not itself inherently toxic, represents an industry that is known for its lack of caution in disposing of waste materials. The mass production process of synthetic indigo was finalised by a German chemical company called BSAF in 1897 as a response to denim’s popularity (facweb.cs.depaul.edu, 2016). Derived from petrochemicals and producing hazardous by-products, synthetic indigo is not an ideal candidate for a sustainably focused denim developer. Due to increased consumer interest (on a business
to business level), companies such as DyStar are developing and offering more sustainable alternatives to regular indigo dyes. An example would be their Indigo Vat 40% Solution Dye, which allows a cleaner denim production and reduces the water usage, produces cleaner waste water and reduces the use of sodium hydrosulphite by 60-70% (DyStar, 2016). If synthetic indigo were to be considered as a stand-alone product, it would be considered a less sustainable part of the development process due to its hazardous origins and polluting effect.

The source of the indigo isn’t the only aspect of the dye to consider, as the form the colour comes in (pigment or dye) can also affect the sustainability. Dye based colours tend to be the less sustainable option as they require many post-processing operations such as steaming and washing. This means a higher use of energy and water that can add up to an extra €27,000 in costs per year, as well as adding time to production runs (Paul, 2015). Pigment based colours are more sustainable options and simply require a one step process using heat meaning less capital investment (as less equipment is needed), less maintenance costs and a shorter production time. Overall a pigment based colour is the more sustainable option.

Alongside the available dyestuffs, dyeing methods are becoming increasingly focused on being sustainable. Normally up to 4,500 threads would have to go through 8-20 baths of cleaning fluids, dyestuff and starch to become ready for the weaving process. These baths produce a large amount of wastewater that often has both excess indigo and sulphites in it which has a very negative effect on the surrounding aquatic life if not treated properly. A big problem with this system is that if the mill wants to change the colour or clean the machines, they lose all of the threads that are still in the machine at that point, leading to large amounts of cotton being wasted.

However there are alternatives that reduce the use of chemicals and water not only in the dyeing process, but also in the washing process later on. For example the denim mill Candiani offers fabric dyed using a method called ‘Indigo Juice’. This method prohibits the dye from penetrating the thread too deeply whilst still retaining a vivid colour on the outside. This means that when the fabric is in the laundry, there is no need for harsh chemicals or abrasions to produce a deep fade. Although this dyeing method itself is not particularly sustainable, it allows for a much more sustainable approach to be taken later on. Another option is their N-Denim method, which saves up to 33% of chemicals and 50% of water due to exposing the threads coming out of the dye to nitrogen (Candiani S.p.a, 2016). This delays the oxygenation of the dye and allows it to penetrate further.
into the thread, causing a more long lasting colour. Another company making progress in this area is Archroma. The main issue with the more sustainable option ("Advanced Denim") that Archroma offers is that it is combined with a new dyeing production line which requires new machinery. Considering that these dyeing production lines can be up to 0.8km in length and have 15-20 separate baths (Archroma Textiles, 2016) as well as various aerating devices and rollers, it is an expensive choice for mills if they want to change. However the Advanced Denim option allows mills to save up to 30% energy, 87% cotton waste and 90% water (Archroma Textiles, 2016).

In conclusion, although natural indigo dye is fully sustainable, it is not sustainable on the large scale that is required by today's denim industry. Synthetic indigo is a less sustainable option, but is a focus point for the industry and is being improved. Using pigment based colours rather than dye based ones is more beneficial both environmentally and financially. When giving examples of branded dyes, Advanced Denim, N-Denim and Indigo Juice would all be considered more sustainable options due to the reduction of chemicals, water use and pollutants. Due to this the dyeing process cannot yet be called fully sustainable, but it is coming close.

<table>
<thead>
<tr>
<th>Fabric Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre</td>
</tr>
<tr>
<td>Key Sustainable Issues</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Key Ethical Issues</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Fig. 4 Assessment of key sustainable and ethical issues affecting fibre and dye choice

Washing

The washing element in the denim development process is arguably the one with the most environmental impact. The use of hazardous chemicals, abrasive stones and harmful sprays produce contaminated wastewater, as well as relying on non-renewable sources, e.g. pumice stone.

Within the washing department there are two overall categories: mechanical and chemical. The table below demonstrates the split between the processes:
<table>
<thead>
<tr>
<th>Mechanical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandblasting</td>
<td>Enzyme Wash</td>
</tr>
<tr>
<td><em>(Unsustainable)</em></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td>Stonewashing</td>
<td>Bleaching</td>
</tr>
<tr>
<td><em>(Less sustainable)</em></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td>Laser</td>
<td>Softening</td>
</tr>
<tr>
<td><em>(More sustainable)</em></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td>Abrasion</td>
<td>Acid Wash</td>
</tr>
<tr>
<td><em>(More sustainable)</em></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td>Water Brush</td>
<td>Tinting</td>
</tr>
<tr>
<td><em>(Fully sustainable)</em></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td>No Stone</td>
<td>Coating</td>
</tr>
<tr>
<td><em>(Fully Sustainable)</em></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td></td>
<td>Potassium Permanganate</td>
</tr>
<tr>
<td></td>
<td><em>(Less sustainable)</em></td>
</tr>
<tr>
<td></td>
<td>Ozone</td>
</tr>
<tr>
<td></td>
<td><em>(Fully sustainable)</em></td>
</tr>
<tr>
<td></td>
<td>Rinsing</td>
</tr>
<tr>
<td></td>
<td><em>(Fully sustainable)</em></td>
</tr>
</tbody>
</table>

Fig. 5 *Summary of washing findings*

Many of these washes have been considered unsustainable or less sustainable due to severe health risks, e.g. sand blasting, or serious negative environmental impact, e.g. stonewashing. The common issue with these is that they use chemicals or reducing agents which then get flushed out with the waste water and either require energy or chemically intensive treatment to neutralise, or do not get treated and cause damage to the local aquatic life.

Happily there are sustainable alternatives that can replicate many desired washes, such as ozone or No Stone instead of stonewashing, or lasering instead of bleaching.

Ozone treatment for denim is an increasingly common option, and is in fact already greener than its chemical or mechanical counterparts. This treatment involves wetting the denim, exposing it to ozone and then rinsing. This process uses 50% less water and 100% less chemicals than traditional bleaching techniques (Bishop, 2014). More benefits to ozone washing include sanitizing the denim, and the only “waste” is clear, pollution free oxygenated air. This option can be fully sustainable when the energy used is from a renewable source, and the water used is recycled in a closed loop system.

By using lasers, patterns or fades can be essentially “engraved” onto denim. The beam burns the top layer of the fibres, removing the
indigo on the surface of the threads. By adjusting the intensity of the laser, you can change how deep it burns and therefore the colour change (e.g. minimal to extreme). With current lasers it is also possible to create abrasions and holes with lasers. A rinse wash is necessary after this procedure to remove any loose fibres, indigo dye and burn marks. Lasering is a more sustainable process when powered by renewable energy, and would require a positive impact on the environment or the workers to be considered a fully sustainable one.

Leaving the fabric raw is not a common option amongst women’s jeans due to the stiff and uncomfortable feel it has until it is broken in (DePrimo, 2014). Raw fabric means that the fabric has not been washed and is in its raw, natural state from the mill, or has only been rinsed to get rid of excess dye. This means that it has a stiff hand feel and is likely to bleed dye onto other fabrics and surfaces it comes into contact with. Many denim purists prefer raw denim as they can then “create” their own unique wash by constantly wearing the jeans and seeing the patterns formed. Another important idea is that by using recycled fibres and then leaving this recycled fabric in a raw state it is possible to save 3.2kg of carbon dioxide equivalents, 59MJ of energy and 130 litres of water per kilo of recycled fibre. This can be considered one of the most environmentally friendly and more sustainable washes as it does not require any energy or washing.

The No Stone technology recently developed by Tonello and shown at Amsterdam Denim Days 2016 is a fully sustainable alternative to stone washing (assuming that it is powered by renewable or green energy and that all water is recycled). The technology consists of stainless steel plates with the textures of sandpaper that can be attached to the interior of any Tonello washing machine. The attachment process takes around an hour, and the plates can be removed at any time. This negates the need for actual stones in the machine, which has many benefits. The first of which is that the machine has a longer use life, as it is not being destroyed from the inside by the stones, therefore also reducing the need for production of machines. The second is that the repeated use of stones in the washing machines leads the stones to break down, creating both small pieces that eventually clog up pipes and sludge at the bottom of the machine that needs to be cleaned and thrown away. This technology can provide a fully sustainable alternative to regular stone washing when the water that is used is recycled, and the energy used if renewable.

The Water Brush is also a machine developed by Tonello, and is an alternative to lasering, potassium permanganate and hand scraping.
The technology works by designing a pattern in the software and then blasting the jeans with a high-pressure jet of water to imprint the pattern. This technique has the benefits of not requiring a neutralisation process as it only uses water, and that the system has been designed to recycle 100% of the water it uses. This means that it produces no wastewater and requires no chemicals at all. By using this technology, it eliminates the need for processes that can create a hazardous work environment such as potassium permanganate sprays and hand scraping which both contaminate the air (through chemicals and dust), thereby improving working conditions. As it has no environmental impact (Tonello, 2015), but it does improve the working conditions for employees, Tonello’s water brush can be seen as a fully sustainable alternative, providing it uses renewable energy.

In conclusion there are washing alternatives available that are fully sustainable when implemented with certain standards put in place regarding energy sources and water treatment.

<table>
<thead>
<tr>
<th>Fabric Choice</th>
<th>Wash Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre</td>
<td>Dyeing</td>
</tr>
<tr>
<td>Key Sustainable Issues</td>
<td>Water use of pesticides</td>
</tr>
<tr>
<td>Key Ethical Issues</td>
<td>Land use of pesticides</td>
</tr>
</tbody>
</table>

Fig. 6 Assessment of key sustainable and ethical issues affecting fibre, dyeing and wash choice

**Trims**

Denim garments often have similar basic trims such as zippers, rivets and buttons. There are already many sustainable options available for these, but the majority tend to look handmade, or do not have the correct aesthetic. Large suppliers like YKK offer sustainable alternatives, however there is still a limited offer.

**Buttons & Rivets**

Buttons and rivets are both solid metal items, however rivets are traditionally made from copper while the buttons are steel (Luiken, 2016). Both are non-renewable sources, and their prolific use on denim products makes it hard to then recycle the garments post consumer use. Alternatives have been explored by brands like Levi’s
who used coconut shell buttons in their 2006 eco jeans launch (Osborne, 2006), or more recently Freitag who used unscrewable buttons on their compostable jeans (Avins, 2015). Coconut shell buttons are a strong alternative, but as they absorb water they become weaker, making it a risk when the denim is being washed. YKK also offers baked metal buttons and rivets which require 70% less chemicals and 54% less water than their regular counterparts, but cost up to 10% more (Herbig, 2016). Although all of these options are a step in the right direction, none can be considered fully sustainable.

Zippers
Producing zippers involves many elements, (tape, teeth, slider, pull tab and stop) each with their own environmental impact. The entire process can involve up to four of eleven high priority chemicals that are being focused on the Zero Discharge of Hazardous Waste Group, as well as including volatile compounds in the paint and adhesive agents used. Many zipper tapes are a blend of fibres, meaning that it is not recyclable and many use polyester, a non-renewable material. Depending on the type of polyester, this could mean that the tape is biodegradable (World Polyester Fibre Report 2010), but often it isn’t. Meanwhile the teeth, slider, pull-tab and stops are often made of stainless steel and then coated in brass or zinc (to prevent rust) or plastic. None of these resources are renewable and there is a very real risk of them running out in the future (Tribuzi, 2014). Luckily there are sustainable alternatives that are being developed and promoted by companies like YKK and TYT. For example under the trade name ‘Natulon’, YKK produces a zipper made from chemically recycled polyester in it’s teeth and slider body that can be recycled. Combined with the reduction in use of crude oil and electricity needed to produce Natulon zippers, YKK has created a perpetually recyclable zipper using a more sustainable method. TYT has taken it one step further and produces a zipper that is made of 100% recycled polymer (sourcedenim.com, 2015) and complies with multiple standards in countries across the EU, Asia and the USA (ecofashionworld.com, 2008). As there is little information available on TYTs ethical standards, this product can only be considered more sustainable, rather than fully sustainable. By recycling plastic waste, TYTs Green Gear zipper is making a positive environmental impact. Although conventional zippers are currently very unsustainable, there are options that are a lot more sustainable with a high chance of becoming fully sustainable.

Leather Patches
Leather patches are, alongside rivets, the most classic trims on denim products. They also represent an industry that has hugely negative environmental and ethical impacts. As leather is predominantly
tanned in third world or developing countries, e.g. in Bangladesh leather exports amounted to $600 million in 2014 (Tarantola, 2014), so workers rights and safety regulations are not strict or enforced. This means that serious injuries at work very likely and can include slips on badly drained floors and exposure to chemicals. The most common chemical is chromium which, when not dealt with using proper safety equipment, acts as a carcinogen and when inhaled as a fine powder irritates the lungs causing a plethora of lung related diseases. When it is absorbed through the skin it causes “chrome holes” which are ulcers on the skin that won’t close as well as irritation, dry/cracked/scaly skin and allergic dermatitis. The environmental impact of leather is mostly based on the waste that the industry produces, from water to solid matter. Tanning one ton of hide produces, on average, 20-80 cubic metres of wastewater which include high levels of chromium and sulphide concentrations, as well as the pesticides added to the hides to stop them decomposing in transit. This contaminated water then causes damage to both the aquatic life and the human life that comes into contact with it. Another waste from the industry is that around 70% of an untreated hide becomes solid waste matter (i.e. hair, fat, sinew and meat).

There are some more sustainable alternatives such as direct recycling, which involves using the same chromium bath for both the initial tanning and re-tanning stages and therefore reduces the presence of chromium in wastewater by up to 21%. A 2002 study that tested in 540 Indian tanneries implies that it is possible to achieve incredibly similar results with a mix of 70% new chrome and 30% reclaimed chrome as with a wash of 100% new chrome (Sustainable Environmental Sanitation and Water Services, 2002). Another alternative that reclaims around 25% of the acid baths chrome is by mixing the acid bath with sodium hydroxide or sodium carbonate (rapid precipitation) or magnesium oxide (slow removal). However all of these alternatives are still considered less sustainable as they have a negative environmental and ethical impact. A fully sustainable option would be to use Piñatex, a leather made from pineapple leaves. The leaves are discarded during the picking of the pineapples and would usually go to waste, and do not require any extra water, chemicals or energy to grow. It also gives pineapple growers and extra income, adding a beneficial ethical impact.

It is therefore currently not possible to use a complete range of fully sustainable trims due to buttons and rivets proving difficult. However zippers and leather patches have more options and can be a good way to make the denim development process more sustainable.
To conclude this chapter, given current innovations and technologies, it is possible to choose and implement a fully sustainable wash, but not a fully sustainable fabric or set of trims. There are fully sustainable fibre choices such as Tencel, but the current dyeing methods can still only be classed as more sustainable. As they continue being updated and can be considered more sustainable as they cut down on water use and release little to no toxic waste, this status looks set to change. Leather patches are the only trim that has a fully sustainable option available (Piñatex), while zippers are considered more sustainable (TYT and YKK). Pure metal trims like rivets and buttons currently do not have any more sustainable options, even though advances have been made and YKK offers some lower impact versions.

**Chapter 5 - The feasibility of implementing a fully sustainable denim development process for a denim company or department**

As highlighted earlier in the report, there are sustainable alternatives to many of the processes and products needed in the development of denim that are technically feasible. This chapter will deal with whether these options are also commercially and practically feasible.

In terms of fabric prices, it has been hard to get specific numbers for sustainable fabrics. However it is possible to make estimations using the average price of a basic denim fabric (made from conventionally grown cotton and using regular dyeing & finishing methods) as a baseline. This is around 3-5€ per metre (Cone Denim, 2016), and that an equivalent using Tencel, Modal or organic cotton costs 5-10% more (Kininmonth, 2016) (Phromvanich, 2016), making it likely to be around 3.15-5.5€. Of course in larger quantities this adds up quickly,

---

**Fig. 7 Assessment of key sustainable and ethical issues affecting fibre, dyeing, wash and trims choice**

<table>
<thead>
<tr>
<th>Fabric Choice</th>
<th>Wash Choice</th>
<th>Trims Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Sustainable Issues</td>
<td>Key Ethical Issues</td>
<td></td>
</tr>
<tr>
<td>Fibre</td>
<td>Dyeing</td>
<td>Washing</td>
</tr>
<tr>
<td>Water use</td>
<td>Water use</td>
<td>Water use</td>
</tr>
<tr>
<td>Use of pesticides</td>
<td>Waste water</td>
<td>Waste Water</td>
</tr>
<tr>
<td>Recyclability</td>
<td>Use of non-renewable resources</td>
<td>Use of non-renewable resources</td>
</tr>
<tr>
<td>Land use</td>
<td>Health issues from use of pesticides</td>
<td>Health issues from untreated waste water</td>
</tr>
<tr>
<td>Health issues from use of pesticides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
for example the price difference on an order of 1000m would be 150-500€. However this is still an affordable option for many companies and departments of all sizes, and is already being implemented by companies from Kings of Indigo to Levi’s.

Making fully sustainable fabric choices is an accessible and feasible option for denim companies or departments of any size looking to minimise their environmental and ethical impact whilst also remaining in a similar price bracket.

For washing there are fully sustainable options, but the capital investment of working in a sustainable manner falls on the denim laundries, and not on the brands using the facilities. This then requires the laundry to rely on companies wanting to use the more sustainable options in order to recoup the investment. Some laundries have become early adopters such as Martelli Lavorazioni Tesilli who already have invested in a more sustainable set of machines. Manufacturers like Tonello are also pushing the boundaries by consistently creating and offering more sustainable alternatives like the No Stone and Water Brush technology. From a laundries perspective the initial investment is quite high, but can be worth it in the long term. By comparing the long term cost of an ozone machine to a stone washing machine (for comparable washes), an ozone machine has a high initial investment of around 20,000-26,000€ while an industrial washing machine rarely costs over 9,000€ (alibaba.com, 2016).

However while an ozone machine requires very little additional costs, the pumice stones required for stone washing are 0.20-0.30€ per kilogram. The rate of use of pumice stones is 1kg for every 1kg of garment, and industrial washing machines can wash loads above 150kg meaning that it can cost up to 22.5€ per wash in stones, or 0.60€ per pair of jeans. On top of this cost the pumice stones inflict irreparable damage on the machines causing them to break down faster. This means that the laundries then need to replace their machines more often, costing them the investment again. This view can also be applied to laser machines (9,000-115,000€) (alibaba.com, 2016), which require little to no maintenance and actually speed up lead times with Jeanologia’s Twin HS laser requiring only 1 worker per shift to finish up to 4000 pairs each day. As well as often having less maintenance or additional costs, these more sustainable machines also often require less water and energy than their regular counterparts.

Implementing a fully sustainable washing process is a very feasible task, but requires laundries to invest in a more sustainable future and denim companies or departments to question their laundries a bit deeper to understand the options on offer.
In terms of trims there are some more sustainable options for zippers, buttons and rivets offered by mainstream companies like YKK and TYT that are not significantly higher priced (buttons and rivets up to 10% more expensive from YKK, (Herbig, 2016)) than regular trims and can be bought in varying quantities. There are innovative and sustainably minded companies like Piñatex who are pushing to create fully sustainable alternatives, (in this case leather for the patches), which don’t settle for having a neutral impact but focus on creating a positive one through both environmental and ethical channels. As this leather is already being used by brands such as Puma and Camper in prototype shoes (Crane. TV, 2015), and so is clearly in the process of being tested as a viable product. This accessibility through price and existing contacts means that it is very feasible for a denim company or department to increase their sustainability through the details.

In total, choosing more or fully sustainable options throughout the denim development process will cost denim companies or departments 5-10% more on fabrics, 10%+ more on trims and potentially less for washes. These higher prices may prove difficult for denim companies or departments who rely on offering the cheapest possible product, or for ones that are just starting up to work with. However, as the price difference is not outrageously high, it is definitely feasible for larger companies to implement a fully sustainable denim development process, or parts of it.

Another aspect to the feasibility of implementing a fully sustainable denim development process is the impact on the end cost, and therefore on the end consumer. Textilwirtschaft’s ‘Das Runde Muss Ins Blaue’ survey in 2014 showed that 81% of people surveyed would want a pair of jeans for less than 100€. In another survey, (consumers view on sustainability in denim and the denim industry survey, 2016), 85% of people indicated that they would pay more for a fully sustainable version of a regular product, but 70% of those who were willing to pay more said they would only be willing to pay an extra €10-€20. This means that a brand’s margin may have to be lower on sustainable products in order to keep consumers interest, which does not gives brand’s much incentive to produce sustainable items. Currently this heavily negatively impacts the feasibility of implementing a fully sustainable denim development process, but as sustainable practices become more mainstream and mass used, the costs involved with naturally drop. This will therefore decrease the retail price or allow brands to increase their margins, making it a more feasible and likely scenario.

Overall implementing a mostly sustainable denim development process is a very feasible one and can be done by companies or departments of any size in most market segments.
Chapter 6 – Conclusion

There are a lot of things a denim company or department can directly influence in terms of increasing their sustainability, such as making a conscious choice about which fibres are considered ‘sustainable’, which washes should not be used and by using alternative trims. However they also heavily rely on other facilities in the process making sustainable choices too, such as denim laundries investing in more sustainable options like ozone or laser machines, or denim mills investing in more environmentally friendly dyeing methods.

A shift towards using fully sustainable denim development processes can be facilitated by educating existing and future members of the denim industry about all aspects of the supply chain and the possibilities within each area. Having a clear, central source of information on the sustainable options within the denim industry would significantly increase the likelihood of brands choosing more sustainable routes, as the information will show clear arguments for the changes. However education isn’t the only key to unlocking the widespread use of a fully sustainable denim development process. The financial implications of making the choice to become more sustainable need to make sense for the denim company or department, as this then affects their end profit and their ability to continue forward. Through more companies working with a sustainable system, the currently expensive procedures or investments will inevitably become cheaper, therefore making it more attractive to others.

In answer to the question ‘To what extent is it possible for a denim company or department to implement a fully sustainable denim development process?’ the research has shown that it is technically possible and commercially feasible for a denim company or department to implement a fully sustainable denim development process through wash choice, and a more sustainable denim development process through fabric choice and trims choice.

Chapter 7 – Product

The final product has been developed in order to fill the need for a central source of information on sustainable choices in the denim development process, and create a platform for denim product developers to connect with mills, laundries and trims manufacturers. Inspired by the Jeanologia’s Environmental Impact Measuring tool and Modint’s Ecotool, the website has an education side that is accessible to all viewers. It’s unique selling point is the retail side which allows those with access a chance to immediately act on what they learn about sustainability in denim by creating and developing
their own sustainable denim development through products available on the website. With a clear and intuitive design, the viewer can easily navigate through the site, and discover deeper information on areas like fibres, washes and trims by simply clicking on the customised logo. The existing website has been created and filled with the information available, however if this project were to move forward there would be a proposed collaboration with several denim mills, laundries and trims manufacturers. This would enable there to be more accurate information on the shopping side of the website, and give more business to the collaborators with minimal effort on their part.

http://graduationprojectemilykenny-troughtonamfi2016.businesscatalyst.com/


References

(alibaba.com, 2016)

(alibaba.com, 2016)
https://www.alibaba.com/trade/search?fsb=y&IndexArea=product_en&CatId=&SearchText=denim+ozone

(Archroma Textiles, 2016)
http://textiles.archroma.com/advanced-denim/

(Avins, 2015)
http://qz.com/492510/compostable-jeans-are-a-thing-now/

(bionicyarn.com, 2016)
http://www.bionicyarn.com/flx.html

(Bishop)

(Candiani S.p.a, 2016)
Candiani S.p.a.. Candiani Denim - Production Process. Print.

(Conca, 2015)
http://www.forbes.com/sites/jamesconca/2015/12/03/making-climate-change-fashionable-the-garment-industry-takes-on-global-
warming/#43562c45778a

(condenim.com, 2016)
https://www.conedenim.com/

(Covolan, 2016)
Covolan, Felipe. 2016. in person.

(Crane. TV, 2015)
Crane. TV,. From Pineapple To Puma. 2015. Web. 18 May 2016.  
https://www.youtube.com/watch?v=ayHE2rEyvjU

(denverfabrics.com, 2016)

(DePrimo, 2014)
http://www.heddels.com/2014/04/raw-denim-options-for-women/

(DyStar, 2016)

(ecofashionworld.com, 2008)

(facweb.cs.depaul.edu, 2016)
http://facweb.cs.depaul.edu/sgrais/indigo.htm

(Fiallos, 2009)

(Fisher, 2015)
http://ecowatch.com/2015/08/17/fast-fashion-second-dirtiest-industry/

(Forbes, 2015) 

(Friedman, 2010) 
http://www.ft.com/intl/cms/s/2/2b27447e-11e4-11df-b6e3-00144feab49a.html#axzz453dbaGi9

(Gielis, 2002) 

(gsrd.com, 2016) 
http://www.gsrd.com/aboutus/

(Herbig, 2016) 
Herbig, Simone. 2016. in person.

(historyofjeans.com, 2016) 
http://www.historyofjeans.com/

(indexmundi.com,2016) 

(International Labour Rights Forum, 2016) 
https://laborrights.z2systems.com/np/clients/laborrights/viewOnlineEmail.jsp?emailId=0442d1ba41854d78dac2bd4f3fbd5a50m0712723044&secureIdCustomer=1&

(Kininmonth, 2016)
Kininmonth, Michael. 2016. in person.

(Lenzing, 2016)  

(Lenzing, 2016)  

(levistrauss.com, 2016)  
http://www.levistrauss.com/sustainability/planet/  

(Luiken, 2016)  

(Made-By, 2013)  
http://www.made-by.org/de/unternehmensberatung/tools/labour-standards-risk-map/  

(McGinn, 2013)  
http://source.ethicalfashionforum.com/article/natural-vs-synthetic-indigo-dyes  

(National Resources Defense Council, 2012)  

(Nudie Jeans, 2016)  

(Osborne, 2006)  
http://www.theguardian.com/environment/2006/nov/24/ethicalliving
(Paul, 2015)  

(Phromvanich, 2016)  
Phromvanich, Vichai. 2016. in person.

(Russell, 2016)  

(Solidarity Centre, 2015)  

(Statisticbrain.com, 2016)  
http://www.statisticbrain.com/denim-jeans-industry-statistics/  

(stellamccartney.com)  

(Sustainable Environmental Sanitation and Water Services)  
http://wedc.lboro.ac.uk/resources/conference/28/Rajamani.pdf  

(Tarantola, 2014)  

Research Report – Emily Kenny-Troughton – AMFI - 2016 34

(Textiles Intelligence, 2012)
Textiles Outlook Intl. (4th quarter 2012), Global Apparel Markets, Textiles Intelligence, Wilmslow

(Textilwirtschaft, 2014)
Anon, “Das Runde Muss Ins Blaue“, vol 20_15, Textilwirtschaft, May 2014

(The True Cost, 2015)

(TreeHugger.com, 2016)

(Tonello, 2015)
http://blog.tonello.com/2015/11/16/tonello-presents-water-brush-jeans-for-humans/

(Tonnaer, 2016)
Tonnaer, Tony. 2016. in person.

(Tribuzi, 2014)
http://www.designlife-cycle.com/zippers/

(Veenhoff, 2016)

(wildcolours.co.uk, 2016)
http://www.wildcolours.co.uk/

wwf.panda.org, 2016
http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/thirsty_crops/cotton/