Exploring life cycle sustainability in the fashion industry

A case study on the impacts in the life cycle of garments and the application of Life Cycle Assessment in a company

B.R. de Haan
Master's Thesis for the Environment and Society Studies programme
Nijmegen School of Management
Radboud University
June, 2017

Exploring Life cycle sustainability in the fashion industry

A case study on the impacts in the life cycle of garments and the application of Life Cycle Assessment in a company

Berber de Haan

For the degree of Master of Science in Environment and Society Studies
Radboud University Nijmegen
Submission date: June 30th, 2017

Colophon

By Berber Reian de Haan
Student number 4797701
Supervision Radboud University by Duncan Liefferink
Supervision WE Fashion by Rebecka Sancho
Nijmegen School of Management
Radboud University
June, 2017
Cover picture by Lian Jonkman via https://stocksnap.io/photo/MWYLJ6SRDM

"The only way to atone for being occasionally a little over-dressed is by being always absolutely over-educated."

— Oscar Wilde

List of tables and figures

Summary

The fashion industry is a multinational business with a growing impact on both the environment and societies worldwide. Many retails and brands, under which WE Fashion, are working to improve their share of the issues that come with growing consumption but with production mainly taking place on the other side of the world this is easier said than done. It starts with getting more insight into the supply chain and the environmental and social issues that accompany it. WE Fashion wants to learn more about its environmental impact through a Life Cycle Assessment from cradle to grave of two of its products, to see how the results can be used. The goal of the research has been to find out where in the life cycle of a t-shirt and jeans the biggest environmental impacts can be identified, in order to help in anticipating the best next step in WE Fashion's CSR strategy and looking at the usability of LCA for other products in the future. To reach this goal, a men's t-shirt and a boy's jeans where selected for LCA research and an explorative social addition. The first product consists only of a main fabric, while the other has several parts like lining, buttons and an elastic band. Information has been collected through surveys, supplemented with database information and processes in LCA software GaBi.

What stands out most in the results of the LCA on the boy's jeans is that the fibre production phase requires a lot of resources, has a lot of outputs and therefore is linked to several impact categories. It might be valuable for WE Fashion to look into the possibility to substitute the conventional cotton for a more sustainable option like better cotton or organic cotton. Wet processing also accounts for a couple of impact categories like water and resource use. Here, the focus might be more on the processes themselves. If a way can be found to do laundry with smaller amounts of water, for example, this might limit the water intake of the phase. Social sustainability is not so easily captured in a quantitative tool, the nature of the data is both too diverse and too sensitive to measure case-specifically for this research, therefore in this case an overview of the most prominent issues in a certain country are explained. WE Fashion already has a consistent auditing system in place, but should watch out for certain hotspots. In Turkey, multiple pressing issues deserve attention while in China excessive overtime poses the biggest problem and in Bangladesh workers involvement and wages should be carefully watched. Overall, life cycle assessment is limited in public use for companies and a more audit like system would be more suitable to measure life cycle environmental impact for WE Fashion's products compared to LCA.

Table of content

1. Introduction

1.1 Problem context

The fashion industry is a multinational business, that has followed the course of globalization over the last years. At the same time, fashion has changed from a concept where small, specialized brands present two to four collections each year, to big retailers adding new pieces almost every week. This change from slow to fast fashion and from local to global markets is not without consequences. While production volumes increase to meet the demand, prices are expected to stay low, so to satisfy these demands most of the clothing production is outsourced to developing countries. This means that the environmental and social problems that follow the industry manifest themselves on the other side of the world. Lacking transparency makes it very hard to see the exact issues that emerge and this has led to consumers becoming increasingly detached from the context in which their clothes were made (Boström & Micheletti, 2016).

But the impact is most certainly there. Synthetic fibres are based on polyester, which is manufactured from petroleum. This process releases an array of hazardous emissions, from carbon dioxide, which contributes to global warming, to hydrogen chloride, which is dangerous for human health (Luz, 2007). Natural fibres like cotton may seem better as they are biodegradable, but cotton cultivation requires almost 65 times more water than polyester production for the same amount of fibre (Fletcher, 2014) and accounts for 11% of global usage of insecticides, herbicides and fungicides (Eberle et al., 2008). Both fibres are then heavily processed before they become the clothes that we buy in stores. The phases of processing materials into garments are linked to environmental issues as well because they require large volumes of chemicals, water and energy. This causes both depletion of resources and pollution at a transnational level, not to mention a threat to human health and questionable working conditions.

The environmental and social impacts of the clothing industry are diverse and global. Since the 1990's the public has become increasingly aware of the issues, especially regarding the working conditions in some of the factories (Kozlowski et al., 2012). Since then, change is on the way. Many clothing retailers nowadays are engaged in corporate social responsibility (CSR) and have strategies to make their products more sustainable. But because production is outsourced, supply chains become more and more blurred for these retailers. In order to really, systematically improve the impact it is very important that clothing retailers have insight into this. Life cycle assessment (LCA) is the most widely known tool for assessing life cycle impact, but it is publically more at home in academic literature than the commercial sector, which is why the practical application is relatively underexposed.

1.2 Host organization and motivation

WE Fashion was founded in Amsterdam in 1962 as a fashion retailer for men's clothing. Since then, it has evolved and expanded to making clothing for men, women and children. Currently, it is an international retailer with stores in The Netherlands, Belgium, France, Luxembourg, Germany, Austria and Switzerland, having almost 250 stores and 3000 employees. The headquarters and distribution centre are based in Utrecht, the Netherland. WE Fashion has its own stores, but can also be bought as a brand in some other stores and webshops. It buys ready-made garments and production sites are not owned by the retailer. For this, it works together with suppliers all over the world.

Over the past years, WE Fashion has actively put in an effort to become more sustainable, and it has adopted Social Corporate Responsibility into its strategy. It is aware of the growing environmental and social problems in the fashion industry and it wants to take its responsibility in this development. The main idea which their CSR report 2014/15 builds on, is the WE Fashion CSR strategy 2020. This strategy is built on four pillars which can be found in figure 1: Better products, sustainable supply chain, sustainable operation and community engagement. The 4 pillars are represented through nine goals, which WE Fashion aims to reach before 2020. These goals in themselves are made up of smaller, but more detailed goals of which the process is measured. Appendix 1 displays the current state of all goals, but this research will mainly focus on the sustainable supply chain pillar. This consists of three subjects: improve social conditions in production, improve the lives of workers and improve the environment in production.

Figure 1: Four pillars of the WE Fashion CSR strategy (WE Fashion, 2015)

WE Fashion already has a consistent system for social compliance in place. It works with the Business Social Compliance Initiative (BSCI), as well as other systems like WRAP and SA8000, on auditing the factories linked to their business partners in order to help improve social standards. However, for environmental impact such a general system is still being developed. This means that right now, the insight into the supply chain regarding environmental impact is limited. In order to get more insight into the environmental impact of its supply chain, as well as the life phases after sale, a Life Cycle Assessment (LCA) research is proposed. This research will perform and evaluate an LCA to find out how suitable an LCA really is for identifying the impacts of products and what can be learned from it.

1.3 Research questions

The overall aim of this research is to fulfil WE Fashion's goal of performing a Life Cycle Assessment in order to see which information can be won from it and how this information can be used, or example to see what it can do in terms of CSR. The main question therefore is:

What is the result of a Life Cycle Assessment performed on two pieces of clothing made by WE Fashion and how can the results be used?

To answer this question, a few sub-question or sub-concepts need to be developed. Firstly, the concept of corporate social responsibility needs to be explained in the context of the clothing industry. The actual life cycle assessment that is performed on two pieces of clothing is key to this research and is performed according to the ISO 14040 standard for life cycle assessment, but small deviations might be possible. The following main question is answered, along with a few smaller questions because the methodology of a Life cycle assessment determines the structure of the research.

What are the results of a Life Cycle Assessment according to the ISO 14040 standard for this garment?

- *What are the goal and scope of the LCA?*
- *What are the results of the inventory analysis?*
- *What are the results of the impact assessment?*

Next, the information that is collected is assessed critically to see what the value of the information is and how suitable life cycle assessment really is for identifying the environmental and social impact of clothing. The last question that is addressed therefore is:

How can the information that is found be used within the company and which recommendations can be made?

Even though WE Fashion already has an established program for social compliance, in the literature as well as business spheres there is no clear, widely used method to measure social sustainability in businesses and more importantly there is not much research on how to combine social and environmental sustainability. Because life cycle assessment only measures environmental impacts, social sustainability needs to be approached differently to see how this can be implemented within a life cycle assessment. There is no ready-made tool for adding social issues to an environmental life cycle assessment, which is why this part will be very explorative and case study specific. It is actually more of a prologue for further research than a vast part of the research question. The question that corresponds to this is:

How can Life Cycle Assessment be supplemented with social sustainability and what bottlenecks exist in doing this?

The structure of the research will be following the research questions. First, the context is set with a theoretical framework, where the choice of LCA is also discussed. Then the methodology is explained, which includes the goal and scope of the LCA because these form the operationalization of the research. Then the inventory analysis is presented, followed by the impact assessment. Using the results, the LCA and social information are interpreted and recommendation are made. Subsequently, an explorative chapter on social sustainability is added, which aims to see what can be said about the social sustainability in the supply chains of the two products.

1.4 Relevance

Academic literature is quite advanced when it comes to the role of businesses in governance and corporate social responsibility. But these researches focus mainly on the reasons that businesses have a big role to fulfil when it comes to sustainability, for instance because of their multinational character. This type of research is often very theoretical and general which makes it a good starting point, but for companies it is too vague to use. Very little research is done on what actually happens on a company level, when it comes to measuring environmental impact in a specific case and how usable certain tools are for a real life company. Even less research is done on social sustainability in practice.

Many fashion retailers like WE Fashion are already working on their environmental and social impact by auditing and investing in more sustainable fabrics like organic cotton. Party because of growing pressure from society, but also because it recognize that the current way cannot be sustained. Because supply chains get increasingly complicated it is hard for retailers to recognize the best next step in terms of sustainability. Most LCA's done by companies are confidential and academic LCA’s might not be applicable 1 on 1 to WE Fashion’s products. Therefore a research like this one is needed, to help retailers in mapping their environmental and social impact and to help WE Fashion identify hotspots in their own supply chain. This research can help companies in general to see what information can be won from a life cycle assessment and how the information can be used. Ultimately, when companies know more and invest more in sustainability this contributes to sustainable development and a better society in general.

2. Theoretical framework

2.1 A quick history of the fashion industry

Before the industrial revolution, clothing production required a lot of time and resources. The cultivation of natural fibres (man-made fibres didn't exist yet) and the processing into the actual garment were so labour intensive and precarious that preserving resources came naturally (Welters, 2015). Even though fabrics and garments where already internationally traded, most steps of production took place in the same region. High-quality clothes were a luxury product that not everyone could afford. Even in this time, clothing functioned as a status symbol and a way to manifest one's identity. Then industrialization started and many processing steps like spinning and weaving could be automated. New inventions came with it and fabrics could also be dyed and printed more easily. This increased the supply of clothing and prices became lower but it also started the emerge of environmental and social problems. For example, waste water would just flow off in nearby rivers (Welters, 2015).

From 1857 the couture system arose in Paris after Charles Frederick Worth opened a dressmaking establishment. This was the first "store" where pre-designed clothes were displayed so that consumers could order a custom fit copy. This shifted the responsibility of designing to the dressmaker and was the start of the labelling of garments (Welters, 2015). With the discovery and wide use of fossil fuels, man-made fabrics were introduced and the production of luxury fabrics like lace became mechanized as well. When close fitting bodices for women went out of fashion, almost all clothes became pre-designed, mechanically manufactured and sold through department stores (Welters, 2015). Meanwhile, this was already the 20th century and big couture labels like Chanel were still working from Paris, presenting two ready-made collections per year.

From the 1950's onwards, after the Second World War, the current way of production really started to develop. The classical way of producing two collections a year was too slow to keep up with the youth's demand for new, quick trends and all around Europe, economies needed a boost to recover from the war. So fast fashion was created: cheap and disposable clothing that is not meant to last long (Welters, 2015). This so-called planned obsolescence is reflected in almost all industries, as buying new things constantly helps the economy to grow (Jonker et al., 2017). But this development was at a cost and therefore it was soon met with resistance. In 1962 a big turnaround was fuelled by the book Silent Spring by Rachel Carson, (Carson, 1962) which showed the environmental damage and impact that chemical use was causing. This concerned the clothing industry in particular, as it was a big user of pesticides and fertilizers worldwide and many wet processes also use hazardous chemicals. But despite the awareness, the clothing industry is still one of the biggest users of both products to date.

Even more problems have come to light, like the extensive water and energy use that are also needed for clothing production. As well as the chemical use, this influences the regions in which the clothing is made as well as the people in it. Low wages, long days and health and safety issues are only a few of the social issues that accompany the clothing industry in developing countries. These problems are reinforced by the driving forces of the clothing industry. Fashion in itself is about change, the nature of fashion compounds overconsumption (Hawley, 2009). Not only because trends changes too quickly, but also because offering new pieces every season makes the clothing industry very economically viable so from an economic standpoint, brands and retailers have no reason to change the current way of working. To make it worse, the clothing industry nowadays produces more pieces than are actually sold, in order to keep the clothing on display and to not to have shortages when demand rises. The results is a big clothing garbage pile.

2.2 Corporate Social Responsibility

It is hard to pinpoint who is responsible for issues that accompany industrial production. For instance, when workers earn a minimum wage below living wage this is based on a governmental law, but clothing companies reinforce this issue by moving their business to factories in these countries and by paying a minimum price for their products. Then when consumers keep buying the cheapest clothing possible, they contribute to the issue as well. Among both scholars and media nowadays the agreement is beginning to form that the responsibility falls in the hands of all three. Where traditionally governments are the big players when it comes to institutional steering, the concept of governance is developing, where governments, markets actors and society all take part in the responsibility (Boström & Micheletti, 2016). For companies, this seems counterintuitive, as the first and foremost goal of a company is to make a profit. According to the classic economic view this is a company's only goal and other activities should only be performed if they contribute to a larger profit (Scherer & Palazzo, 2011). But since awareness about sustainability is growing, both NGO's and consumers are beginning to question the circumstances under which products are made (Seuring & Müller, 2008[1]) and the international character of some companies gives them a good position to set certain standards, especially in countries where the government fails (Matten and Crane, 2005).

When companies recognize their share in issues and take responsibility that go beyond the legal rules, connected to social and environmental sustainability this is called Corporate Social Responsibility. The definition of CSR, as stated by the European Commission is "A concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholder on a voluntary basis" (European Commission, 2011). It is also often linked to the definition of sustainability, which is about meeting current needs without compromising the needs of future generations (Brundtland Commission, 1987). CSR, in this case, is meeting the needs of current stakeholders, without compromising the need of future stakeholder (Dyllick & Hockerts, 2002). These stakeholders can be defined in a very broad way, including not only employees, consumers and other actors but also the environment, along the whole supply chain (Amaeshi et al., 2008). Even though the term only includes the word social, in most cases environmental sustainability is also implied and because this is about the business sphere, the economic sphere is at the base. Trying to integrate social, ecological and economical sustainability is called the triple bottom line approach (Seuring and Müller, 2008[1]).

What corporate social responsibility really entails differs between companies and evolves over time, but it is often seen as a umbrella term for a strategy for sustainability within a company. Within CSR, many approaches to sustainability exist, accompanied by several different tools. For international companies like WE Fashion, these approaches do not just include the focal company, which is the main company that governs the supply chain, but more importantly at least part of the supply chain.

2.2.1 Sustainable supply chain management

When a focal company wants to involve their supply chain in their CSR strategy more issues come up. Most clothing companies do not own the factories in their supply chain, the factories have their own management and their own rules. Focal companies often buy ready-made garments from a supplier, this supplier works with producers or buys its resources from another supplier and so on. This means that transparency into the supply chain can cause some problems, not just for consumers but for focal companies as well. So while focal companies can stimulate their suppliers to implement a more moral management system, they cannot force them, which increases the challenge for CSR in the fashion industry (Kozlowski et al., 2012).

Nonetheless, trying to implement CSR through the whole supply chain makes way for a holistic approach to sustainability. Scholars call this sustainable supply chain management, which Carter and Rogers (2008, p. 368) define as: "The strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains". Note that the three pillars of sustainability are mentioned in the definition; environmental, social and economic sustainability, so the triple bottom line applies here as well. It is the most complete and holistic aim for sustainability, but also the most complicated one to implement.

The strategy where a company wants to improve the environmental and social quality of a product is what Seuring and Müller (2008[1]) call supply chain management for sustainable products. In this strategy, environmental and social standards are set in order to meet customer demand and gain competitive advantage. The nature of these standards can greatly vary, from limited chemical wash out in the final product, to the absence of child labour in cotton cultivation. Before any of these standards can be set and complied with, a company needs to have enough insight in their supply chain first but this insight is often limited to the first-tier suppliers (Seuring and Müller, 2008[1]). Because of this, life cycle assessment is one of the most relied on methods for this strategy. As figure 2 displays, the focal company needs information on the impacts and requirements in the life cycle of the product, in order to make more sustainable products.

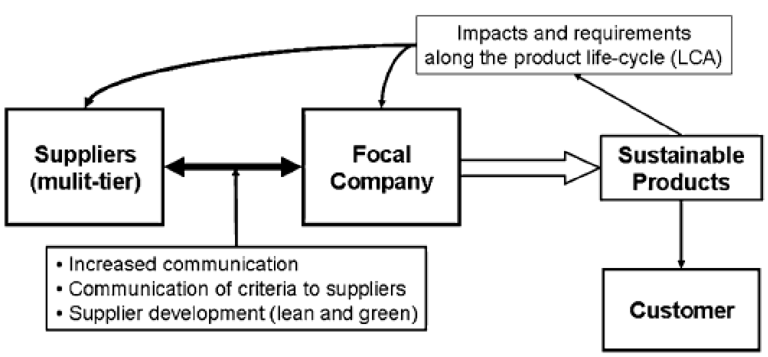


Figure 2: Supply chain management for sustainable products (Seuring and Müller, 2008[1]).

2.3 Environmental sustainability

It is quite clear how the planet can be used unsustainably in the literal sense: by using up resources more quickly than they can replenish and adding substances to the atmosphere more quickly than it can stabilize them. According to a research by the Stockholm Resilience Centre we are approaching the natural boundaries of our planet because we are using up resources in a rate that will lead to a turning point where things will not go back to how they used to be (Rockström et al., 2009). This report is often used to visualize environmental sustainability: the ability to sustain this way of living within the natural boundaries of planet earth. Several environmental issues are included in this, for instance climate change, land use change, biodiversity loss and several others, as is shown in figure 3. This figure also shows the current operating levels of these issues and for some the rates have already passed the proposed safe levels. It is expected that crossing these lines will lead to an irreversible state that will pose great threats to human life. From an ecocentric standpoint one might argue that even if human life wasn't threatened we should still fight going over this tipping point as nature has intrinsic value and should be protected regardless of our own self-interest (Gladwin et al., 1995).

Some environmental issues that are mentioned in the planetary boundary model like climate change, fresh water use and nitrogen imbalance can be linked directly to the clothing industry. For instance, in some areas like India, cotton production is very energy intensive, because of the poorly regulated irrigation systems (Thind et al., 2010). This also means that water is used inefficiently and a lot of fresh water is needed. Chemicals that are in this water can flow out into the soil and because of evaporation, contaminate the ground which changes the nitrogen balance (Steinberger et al., 2009). In line with the strategy for a supply chain for sustainable products, life cycle assessment research could help to identify exactly what the share of the impact of certain garment is and what their relation is to the planetary boundaries model.

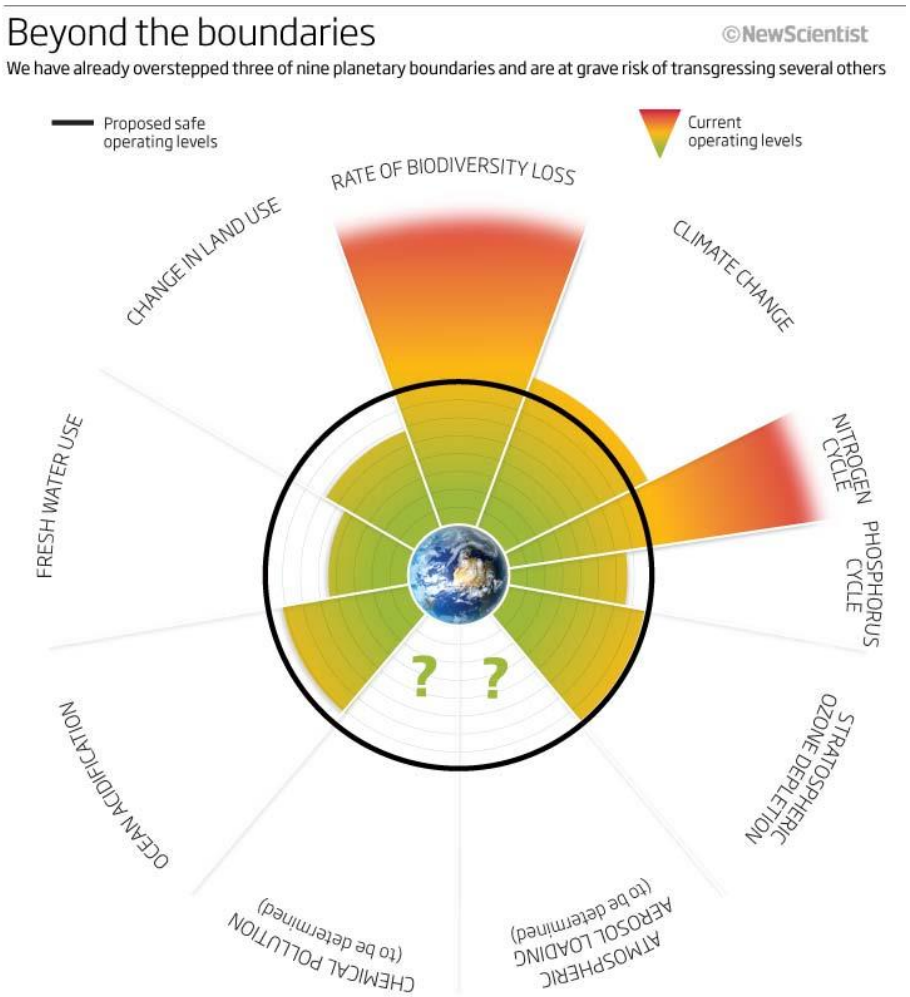


Figure 3: Planetary boundaries and the current operating levels of several sustainability issues (Agyeman, 2012).

2.3.1 Life cycle assessment

Life cycle assessment is a basic framework that helps with recognizing environmental problems throughout the supply chain and even the whole life cycle of a product. It looks in detail into each phase of a product's life, starting with the cradle, where the raw material is extracted and ending in the grave, the disposal phase. Through LCA one can identify which flows go in and which flows come out of each phase of the product system. This quantitative inventory can then be used to analyze what environmental impacts can be linked to certain life phases (Baumann & Tillman, 2004). But despite the quantitative nature, LCA research depends heavily on the conductor's choices and thus includes some subjective elements. For this reason, the term life cycle assessment was preferred over life cycle analysis when the concept first was created (Baumann & Tillman, 2004). It now recognizes that analysis is a more objective part of the more subjective assessment in general.

Figure 4 shows the basic structure of an LCA. First the goal and scope of the research need to be defined. Then all the in- and outputs are inventorized and then analyzed. From this, an impact assessment is made, by linking certain substances to environmental issues, like CO_2 and CH_4 to climate change and CFC-113a to ozone depletion. Many of the environmental issues that are researched through an LCA stem from the planetary boundaries model in figure 3, as it depicts the most urgent environmental problems. The complete explanation of the environmental impacts and the rest of the methodology will be discussed in the coming chapters.

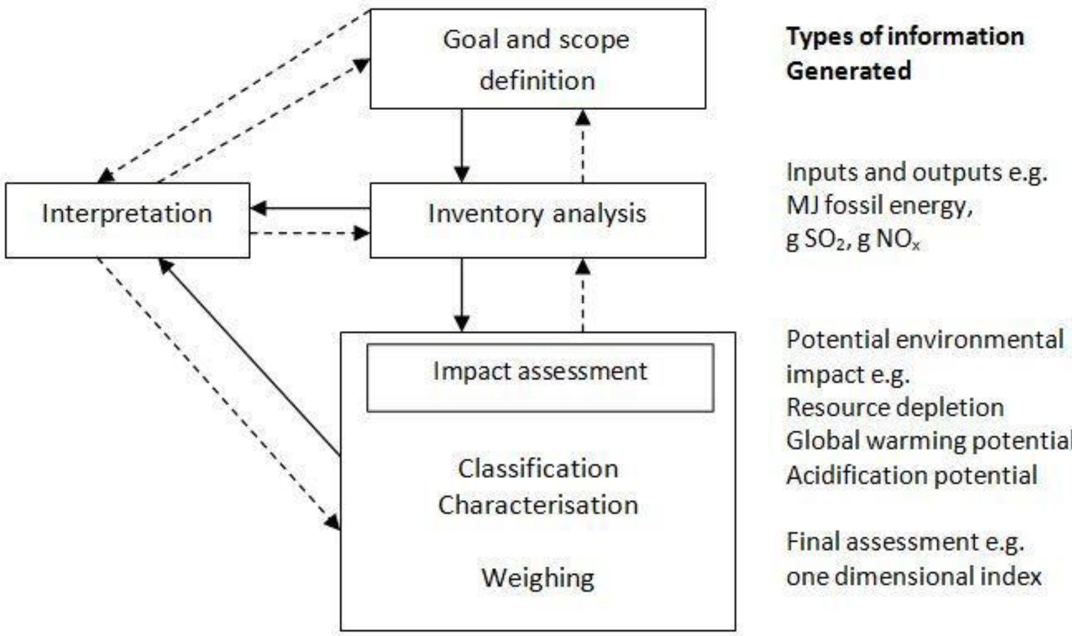


Figure 4: The LCA procedure (Baumann & Tillman, 2004, p. 20)

Life cycle assessment is one of the most extensive tools for sustainability because it studies the whole product system and it gives insight into the relationships within it. Furthermore it shows what part of its life makes a product unsustainable and what alternatives might change the environmental impact. This can help buyers to make more sustainable purchase choices (Lamming & Hampson, 1996). In the end, it is a technique that was developed for product-oriented sustainability (Pesonen, 2001) and it can be used in decision making regarding environmental issues (Hagelaar et al., 2005). While many other system analysis tools are also useful in assessing sustainability within a company, like cost-benefit analysis none of these focus on the supply chain of a product like LCA (Finnveden & Moberg, 2005). Other tools like Design for the Environment or Industrial ecology offer great new options for a company (Lozano, 2012), but these are follow-up steps that require certain knowledge: what is the impact one should account for in the design of a product, where can waste streams be connected? This information might be found in the result of a life cycle assessment, which is also a reason to perform it first. LCA can be seen as a first step for exploring sustainability in a product's life cycle.

Some LCA research on the life cycles of t-shirts and jeans already exists, most of it done by academic authors or research bureau's rather than companies (Defra, 2009; BIOIS, 2007; Browne et al., 2005). These researches are mainly based on database results and focus on the whole life cycle with equal weight. Doing a research within a company, with actual empirical results from their supply chain might yield different outcomes, which is why for this research a new, explorative life cycle assessment is performed from scratch. But also because WE Fashion wants insight into their specific impact, rather than a general environmental impact. How the different types of researches relate to each other is interesting to discuss in a later stadium of the LCA, like the critical review.

LCA research is a challenge for companies because products are often manufactured in several different factories and the fabrics and fibres are even more diversified so supply chains are very hard to trace back and they are made up from the natural and industrial system so both agricultural and manufacture processes need to be measured in the same terms (Kozlowski et al., 2012). These issues make LCA more subjective, but that doesn't necessarily pose a problem for the usability. It influences the way one should approach interpreting the results: not by blindingly accepting them but by comparing them with other researched and looking at it in context to see where the most improvement can be made by the company itself. Another fickle point it that LCA research only focuses on environmental sustainability, while the clothing industry is a very labour intensive industry and the main controversy in clothing revolves around social issues. Both Kozlowski et al. (2012) and Hunkeler and Rebitzer (2003) say that the use of LCA can be greatly improved when social and economical aspects are included.

2.4 Social sustainability

Social sustainability is a little less obvious compared to ecological sustainability, but it can be explained as follows: when people are working in unhealthy or unsafe conditions they might become ill or injured. Not only is this technically unsustainable for the company because these people are unable to work, but their basic human rights and lives might also be in danger. It is about the way human capital is treated (Dyllick & Hockerts, 2002). In a sense, ecological sustainability is a part of social sustainability as it can influence human lives. In practice, what social sustainability entails is not easily quantified and depends on the industry (McKenzie, 2004) but in the clothing industry it is quite generally known which social problems are present, newspapers continually write about issues regarding child labour, injuries and fatalities, poverty, gender equity and collective bargaining (Noordhollands Dagblad, 2017). Although not applicable everywhere this gives an idea of which kind of issues are covered by social sustainability.

While research and tools on social sustainability lack a bit in academic literature compared to environmental sustainability, in reality in the clothing industry it is actually more advanced. After the collapse of the Rana Plaza in Bangladesh in 2013, a lot of attention was drawn to the bad working conditions in which garments are produced (The Daily Telegraph, 2013). Many focal companies, including WE Fashion, have responded to this by joining initiatives like the Bangladesh Accord, which asks that brands take measures in order to avoid such calamities in the future. Furthermore, several programs for social auditing exist, the biggest independent one for small and medium size businesses being the Business Social Compliance Initiative (BSCI), WE Fashion is a participant of this program as well. This organization hosts a platform on which participants have insight into the suppliers and producers in their supply chain and where audit reports and the accompanying remediation plans are shared. They also have one of the biggest, well know standards for audits, which scores the producer on categories like no child labour and health and safety, but also on fair wages and working hours.

2.4.1 Social compliance and the supply chain

Even though programs like the one that is described above have a big impact, they only cover a small part of the product system. Audits are mainly performed in garment producing factories and the further you go back in the supply chain, the less is monitored. So there the social situation may be a lot worse. This means that there is still some work to do when it comes to identifying social issues in the supply chain and it would be good to try to integrate social sustainability into what in essence is an environmental life cycle assessment. Freestanding social life cycle assessments research on the clothing industry has for instance been done by Zamani et al. (2016), who try to identify the hotspots of the clothing industry to show where the most risk occurs for social issues, but they already mention that this is no complete and general method for assessing social sustainability.

The tool closest to LCA is social life cycle assessment (SLCA). Despite being holistic and extensive like normal life cycle assessment, it is problematic for this research because of a number of reasons. Firstly, the difference in the nature of the data; some aspects can easily be measured like over hours and hours of child labour, but social issues like health and well-being cannot be measured with the same benchmark, which is important to keep this in mind when choosing indicators for social problems (Weidema, 2006). Secondly, measuring your data for a social LCA is hard because social indicators depict the circumstances of the production location of the product, not of the product itself. This means that producers are a lot more hesitant to reveal the exact social impacts, compared to the environmental impacts. Lastly, because SLCA it is not as widely spread as environmental life cycle assessment, the methodology is not well developed yet and therefore an SLCA would be too complicated and time-consuming in this context.

So in this research the social sustainability part of the research will not be based on a specific research method, but it will be a qualitative and explorative combination of the literature and WE Fashion's social policy. As the life cycle assessment will reveal the steps of the supply chain for each product, this will be the starting point to see how far we can get into the supply chain regarding social issues and which bottlenecks can be found to measure this impact like the environmental impact. As the social side of the issue is not part of the empirical study and the main goal of WE Fashion, it is added more as a bonus in an explorative chapter at the end.

3. Method

3.1 Case study and research strategy

Because this research will be in collaboration with WE Fashion and a couple of their products will be assessed, the research approach is a case study research. This research will go in depth and answer very focused questions about a specific subject in a relatively short period of time (Hays, 2004). The goal is to help WE Fashion to get understanding and insight into their sustainability impact, but that doesn't mean that none of the results can be generalized. By focusing largely on the method of assessing the impact, the recommendations based on the results might still be useful for other companies or scholars as well and several case studies about the same phenomenon together can form a more representative, ethnographic theory about where the biggest issues in the clothing companies can be found and approached for improvement (Hays, 2004), so the results will also be compared to other LCA's.

When doing a case study, one first has to select the site at which the case study will take place. In this case, the case is chosen because of the collaboration with WE Fashion. Even though the base of the study is WE Fashion, in reality it also includes other companies, namely the factories and suppliers in the supply chain. Furthermore, the life phases after a product is sold will be taken into account as well. So the unit of analysis, the unit where all data for the research is collected (Hays, 2004) in this case is the life cycle of two pieces of clothing, sold by WE Fashion.

In order to collect the right information to answer the main question, different methods can be used. Often, the method is chosen through looking at the right research strategy for the question and depending on the nature of the information that you want to collect, qualitative or quantitative. In this case, WE Fashion has requested LCA research, as it is an internationally recognized method that is recognized by their business partners. Furthermore, in chapter 2 on theory, it is argued why this is a suitable method for measuring the environmental impact of clothing articles, namely because it is a first step in determining which CSR tools can be used next and because of its holistic approach. For the social impact a very different approach with a more qualitative focus is used, based on academic literature and examples from an auditing system.

The rest of this chapter will elaborate on the first step of the life cycle assessment: the goal and scope definition. The goal and scope definition of a life cycle assessment actually represents the methodology because it sets the rules and boundaries for finding and analyzing the results. Like a normal methodology chapter it defines the goal, reasons for the research and target group. Also the operationalization is done here and the system boundaries are set, which is why the first part of the LCA will be merged with the methodology and will be explained below.

3.2 Life cycle assessment

The methodology of a Life cycle assessments starts with a goal and scope definition. It is important to clearly define why the study is carried out, what the indented application is and for whom the results are intended. Not only does it guide the research, but it is also mandatory through the ISO 14040 standard. The goal and scope of this research are discussed between the commissioner, in this case WE Fashion and the practitioner, who is the writer of this research. Usually the commissioner has an idea of what he/she wants to know and the practitioner then comes up with a way to answer those questions best.

3.2.1 Goal

The goal of a life cycle assessment has to be very specific, as the ISO 14040 (2006) states: " the goal definition shall unambiguously state the intended application, the reason for carrying out the study and the intended audience". Being specific and making clear choices is important for the methodology, as life cycle assessment does depend on the practitioners choices and allocations (Baumann & Tillman, 2004).

WE Fashion would like to know where in its life cycle the biggest environmental impact can be found so that it know what the next best step is in terms of their CSR strategy. Depending on the results it might change something in the design phase of the products, influencing the supply chain or the use of the product to become more sustainable. It is also interested in the development of a general approach to LCA, so that it can be used again in the future for a different product of their choosing so it should be very well assessed how suitable LCA is first. Although the results of the LCA might be used to change something in the future, the LCA itself is attributional rather than consequential, as no alternatives are discussed (Weidema, 2003) and it is simplified, rather than detailed because of limitations in time and means for the research. This means that some parts that are mandatory in a detailed LCA, like the external critical review are left out.

So the intended application of the research is for use in WE Fashion's CSR strategy and to find out if anything can be changed in the design of a product to make it more sustainable. The reason for carrying out the research correlates with this, because it would contribute to their CSR strategy for environmental sustainability. The intended audience are internal actors like designers as well as stakeholders. This means that the goal of the study, defined together with the CSR manager and the Social Compliance manager, is as follows:

"The goal of the research is to find out where in the life cycle of a t-shirt and jeans the biggest environmental impacts can be identified, in order to help in anticipating the best next step in WE Fashion's CSR strategy and looking at the usability of LCA for other products in the future"

This goal is more specific than the overall goal of the research, which is to perform an LCA and see how the results can be used. This goal, the goal of the LCA, specifies the intended application of the results as formulated by WE Fashion. Whether or not the results can actually be used for these application will show after the LCA is performed.

3.2.2 Scope

The scope of LCA research focuses on the specifics of the modelling. The goal is still quite broad, as in this research two different products will be assessed, which have different life cycles based on their composition. However, their function is the same: to be worn. LCA research requires a functional unit, which is basically a quantification of the function of a product. It is based on the reference flow, the amount of product that is needed to fulfil the function, so it acts as a general measuring unit that is set in order to normalize all the information needed for the assessment (Baumann & Tillman, 2004). The function of a garment is to be worn, we need only one piece of garment to wear at a time, so the functional unit is a single t-shirt, worn for 100 days and a single pair of jeans, worn for 1 year. The time unit is needed to account for the use phase and is based on other LCA research for garments, where 100 days is seen as a reasonable wear time for a piece of garment for a t-shirt (Steinberger et al., 2009), but jeans are more sturdy and can be worn up to three years, however because it is a children's jeans it is assumed that it is worn about 1 year.

In the following paragraphs, the different specifics of the research are reviewed. Details like which garments are used, the system boundaries and the impact categories will be explained so that it is clear what is included in the research and what is not.

Selecting garments

Together with the CSR department at WE Fashion, two garments have been selected for the LCA research, varying in material composition, complexity and target audience. The chosen garments are either from the main collection, or very generic and similar products appear in new collection over again. Production volumes are therefore relatively big for these garments. This makes the research more representative and more widely usable for WE Fashion. Below, in table 1 and 2 is the technical information on the selected garments.

Men's t-shirt technical details

Product description	Short-sleeved men's t-shirt with print
Size	M
Main material	
Composition	100% cotton
Mass	120,96 g

Table 1. Technical details for the men's t-shirt

Boy's jeans technical details

Product description	Boys jog denim jeans
Size	Kids size 158
Main material	
Composition	99% cotton, 1% elastane
Mass	404,45 g
Lining	
Composition	100% cotton

Mass	22,41 g
Plastic buttons	
Composition	Polyester resin
Mass	0,9 g
Metal button and zipper	
Composition	Brass
Mass	9,06 g
Elastic band	
Composition	Elastane and polyester
Mass	4,51 g
Faux leather patch	
Composition	Synthetic leather
Mass	1,66 g
Total mass	**442,99 g**

Table 2. Technical details for the boy's jeans

Defining system boundaries

The products above have different life cycles, based on their materials and compositions. In narrowing down the phases of the life cycle that will be assessed we are defining the system boundaries. These are based on cut-off criteria and determine which processes are and aren't modelled, based on relevance and also on whether or not an effect is negligible (Baumann & Tillman, 2004). In this case, all life phases can be of influence on the sustainability of a t-shirt, including the use and disposal. Moreover, these can also be influenced by the focal company, for instance by designing clothes that need to be washed in a specific way or by offering a recycling program. This research measures from cradle to grave, which means that all phases of a product's life are included, from resource extraction to disposal.

Because WE Fashion wants to know what it can do in terms of CSR, the main focus in on the supply chain and therefore on the cradle to gate exchanges. Collecting empirical data on the use and disposal phase would require a different approach, where for example costumers are interviewed to see how they care for their clothes and how they dispose of them. This would be a good addition, but it is not included in this research because limited time and possibilities, instead general information and assumptions are used, but the specifics of the data collection will be discussed later on.

The system boundaries include several types of boundaries, for instance to the natural and technical systems but also geography and time. Natural boundaries decide the begin and end of the life cycle, so the cradle and the grave. The phases that are included are part of the technical system and are generally all phases under human control, for instance for oil, this means that the life cycle begins when it is pumped from the ground (Baumann & Tillman, 2004). But for cotton this is harder to define, is the soil where it is grown for instance part of the technical system? Or the natural system? And if soil is included, then should you also include the electricity of the building in which yarn is produced? This discussion is about whether to include background processes, as well as the foreground processes. Based on the systems boundaries that are chosen these can be included or excluded. For an example, see figure 5. Here you see that energy is an input for bleaching, but the process of energy production has its own inputs and outputs which can also be modelled. Doing this makes the research more reliable, but a lot less feasible.

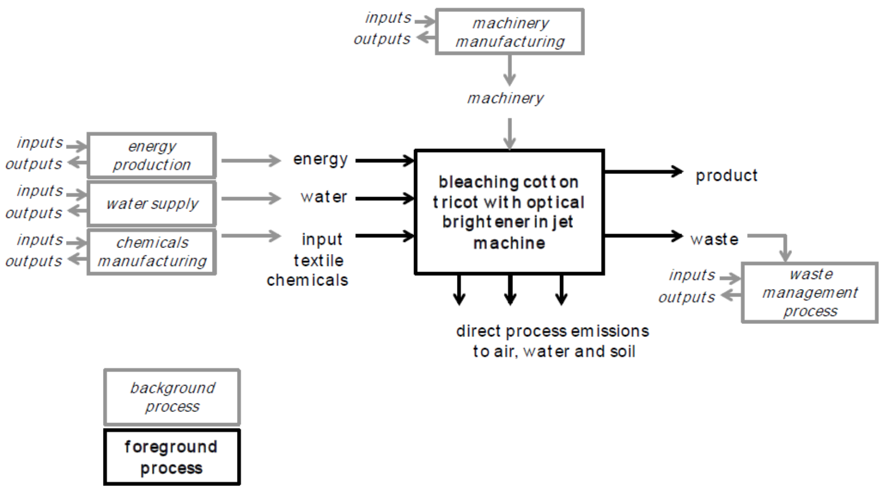


Figure 5. Foreground and background processes than can be in- of excluded from an LCA (Roos, 2016)

This is a point which also shows the subjectivity of an LCA and why the boundaries have to be defined clearly in order for the research to be valid. In this case, the background phases will not be modelled because of the limited time and resources for the research. A large part of the system is situated in other parts of the world and it is already a challenge to get the right information from the supply chain. Asking about the energy production of chemical manufacturing further back in the chain is not realistically achievable. Figure 6 shows the chosen system boundaries, which focuses on the foreground processes. The elementary flows that go into the system, like land use and fossil fuels are called negative emissions and the elementary flows leaving the system, like emission to air, soil and water are called positive emissions.

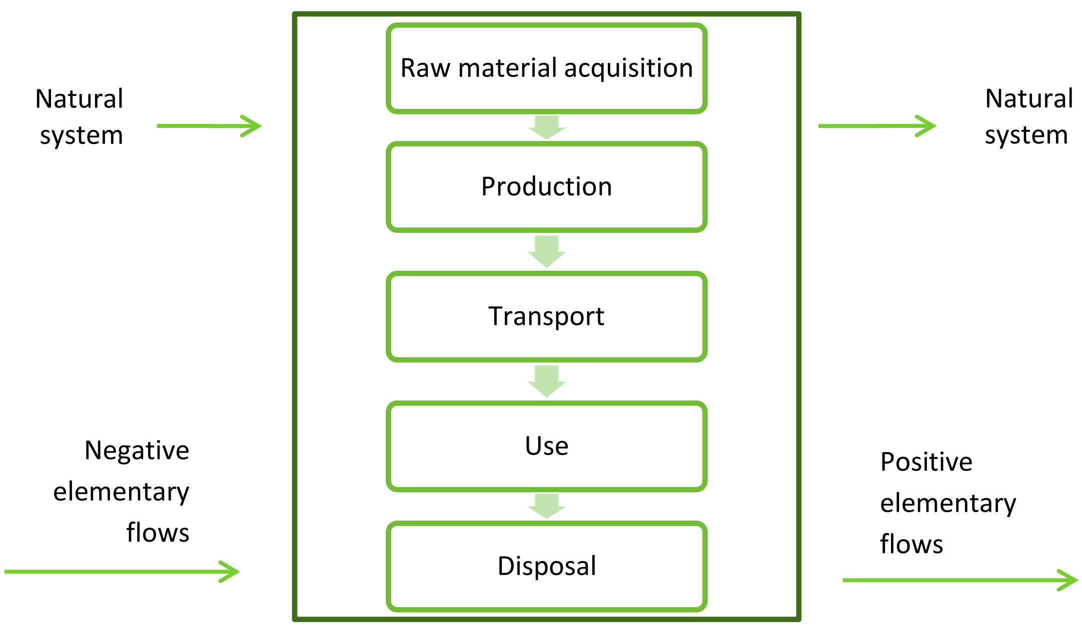


Figure 6. System boundaries and flow diagram

However, the influence of the main company is not as strong everywhere in the life cycle, as is displayed in figure 7. This figure displays the retailer, in this case WE Fashion, in the middle. It is linked to suppliers, who are in their place linked to subcontractors who have their own links. On the right, you see that the further the links are away from the focal company, the weaker the influence is. This applies both to the producers upstream, as well as downstream, to the consumers. In the case of WE Fashion, it is a retailer, brand and distributor in one, so downstream it is in direct contact with costumers but also works together with some other retailers. Upstream, it is in contact with suppliers, who work with direct or indirect factories, who in their turn work with material producers like it the figure. The further away in the chain, the less influence it has and the harder to get the right information for the LCA.

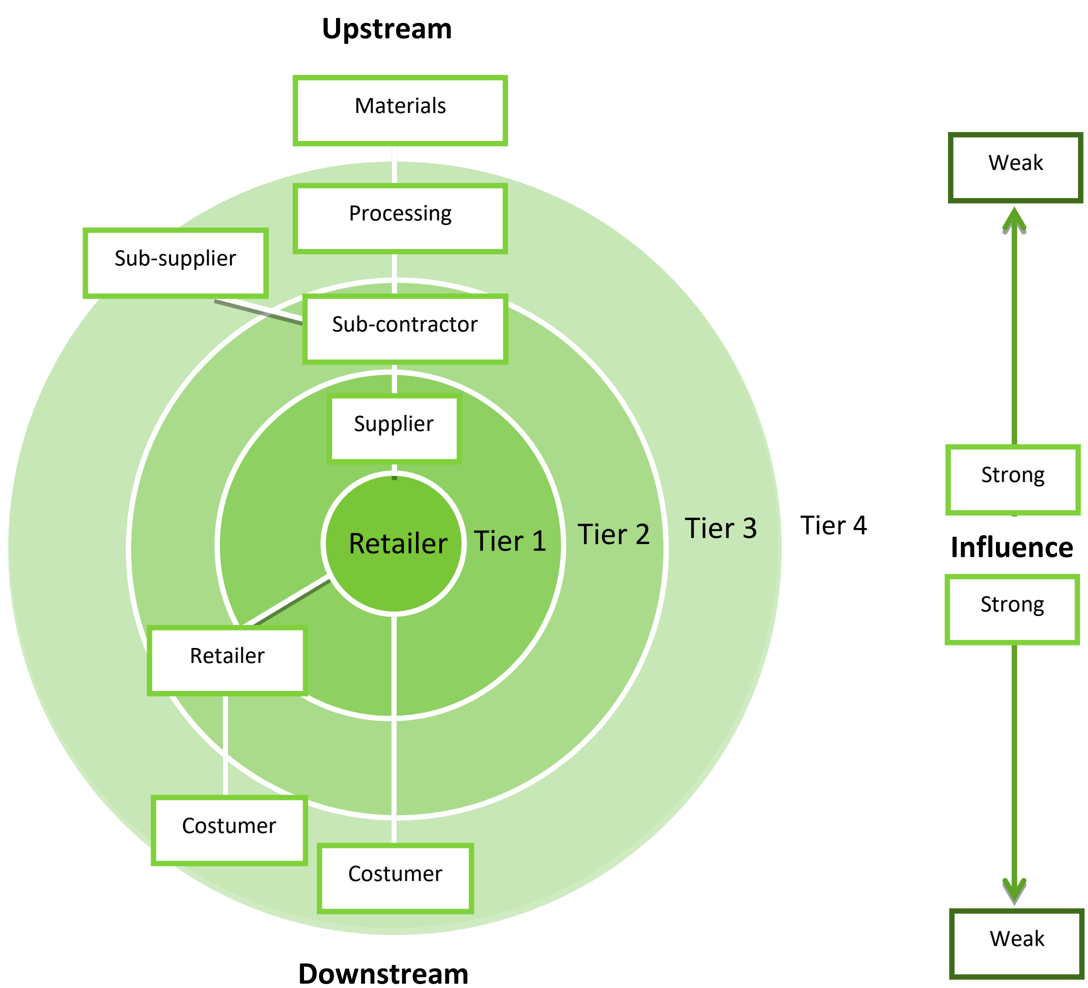


Figure 7. Example of supplier tiers in the value chain of a retailer

Geographical and time boundaries

Part of the reason that it is so hard to model the complete system for clothing is because of the geographical scale in which the supply chain is situated. The figure above is spread over different parts of the world. Materials like cotton can be from the US, then fabric and garment manufacture happens in Asia for a t-shirt that is worn and discarded in Europe. To get from one place to the other, the fabrics are transported, which also needs to be modelled. Accounting for geographical differences is important because different regions are more or less sensitive to a certain type of impact (Baumann & Tillman, 2004). Arid areas for example can have water shortages, so if a lot of water is used for production there is tension between the two. For each product that is modelled, the geographical journey will be described. The time boundary is especially important when measuring impact over a certain amount of time, or measuring progression. This research will not do that so mentioning that it is performed in 2017 is enough.

Allocation

Production does not exist in a vacuum, different products can share the same processes, which makes it hard to know which impact should be attributed to which product. This is called the allocation problem and there are three ways in which this can pose a problem in LCA. The first is multi-output, where different product come from the same processes. A certain fabric can for instance be cut to make t-shirt, but maybe tank tops as well. This can be solved by researching which share of resulting products falls within your system boundaries, to measure the impacts accordingly. In this research this is accounted for by measuring inputs and outputs for a certain weight of the product. The second is multi-input, where several products end in the same waste treatment process. The last is open loop recycling, where one product is recycled into different new products (Baumann & Tillman, 2004). In these cases, you have to allocate which impacts to include and how, but preferably this should be avoided, as it adds a certain subjectivity to the research. These last two options do not apply to this research.

Options to avoid allocation are to increase the level of detail or to expand the chosen system boundaries (Baumann & Tillman, 2004). But in practice this is very hard because this means you can keep adding processes and products, which makes the research unrealizable. Therefore in this research the problem will be fixed by partitioning between systems functions based on mass. This is done through the design of the surveys, which ask for the input in weight and the output in weight of for instance cotton fibre so that it is clear which share that comes out is part of the product system. In case the surveys do not yield this information, it will be calculated later on.

Impact categories

There are three general impact categories, also called areas of protection or safeguard subjects (Baumann & Tillman, 2004) that are used in almost all LCA research, these are resource use, human health and ecological consequences. Often, they are divided into more specific categories like acidification and global warming potential but some categories fit into multiple areas of protection. Which impacts to choose can be based on standard LCA sets, but these can be adapted a little to fit the product. In choosing the categories it is important to be complete and not let out any types of categories without explanation but still be practical and not include too many categories, also to avoid overlap. Lastly, scientifically based indicators, which have earned international consensus make the research more valid (Baumann & Tillman, 2004). Table 3 shows a list of impact categories as well as their geographical scale and whether or not there is international consensus on the classification and characterization.

Issues like global warming and fresh water use are widely associated with the clothing industry, but for instance nutrient enrichment, which is a less widespread problem also has close connections to cotton production, because of washout of fertilizers. Based on table 3, as well as other comparable LCA researches (Zhang et al., 2015) the following impact categories are selected to be researched. Many of the categories that are mentioned under ecological consequences are also applicable to human health, as humans also depend on the ecological circumstances.

Resource use

- Water use
- Resource consumption / abiotic depletion

Human health

- Human toxicity

Ecological consequences

- Global warming potential
- Eutrophication potential/nutrient enrichment
- Stratospheric ozone depletion
- Acidification
- Ecotoxicity

Impact categories	Geographic scale				International consensus	
	Global	Regional	Local	Working Environ-ment	Classification	Characterisation
Global warming	x				yes	yes
Stratospheric ozone depletion	x				yes	yes
Photochemical oxidant formation		x	x		yes	(yes)
Acidification		x	x		yes	(yes)
Nutrient enrichment		x	x		yes	(yes)
Effects of waste heat water			x		no	no
Ecotoxicity		x	x		(yes)	no
Human toxicity		x	x		(yes)	no
Working environment				x	yes	no
Odour			x		yes	no
Noise[1]			x		(yes)	no[(1)]
Radiation					yes	no
Resource consumption	x	x	x		yes	(yes)
Land use			x		(yes)	no
Waste			x		(yes)	no
Effects on eco-systems					no	no

Table 3. Characterization of environmental impact categories (Stranddorf et al., 2005).

Initial flowchart – generic life cycle

Figure 8 shows the generic life cycle of a piece of garment and the in- and outputs of each life cycle that will be modelled. In short, the different phases of the life cycle are the fibre production phase, the yarn production phase, the fabric production phase, the garment production phase, transport, use and disposal. All phases will be included in the LCA, with a main focus on the cradle to factory gate, which is displayed darker in the figure. More information on the data collection for each phase is discussed in chapter 3.3.1. Within the life phases, some processes might have a higher impact than others, which is why some of these processes are already specified in this figure. The second part of the figure shows which inputs and outputs are asked for in the survey that is sent to the suppliers. The results of the survey are discussed in the inventory analysis.

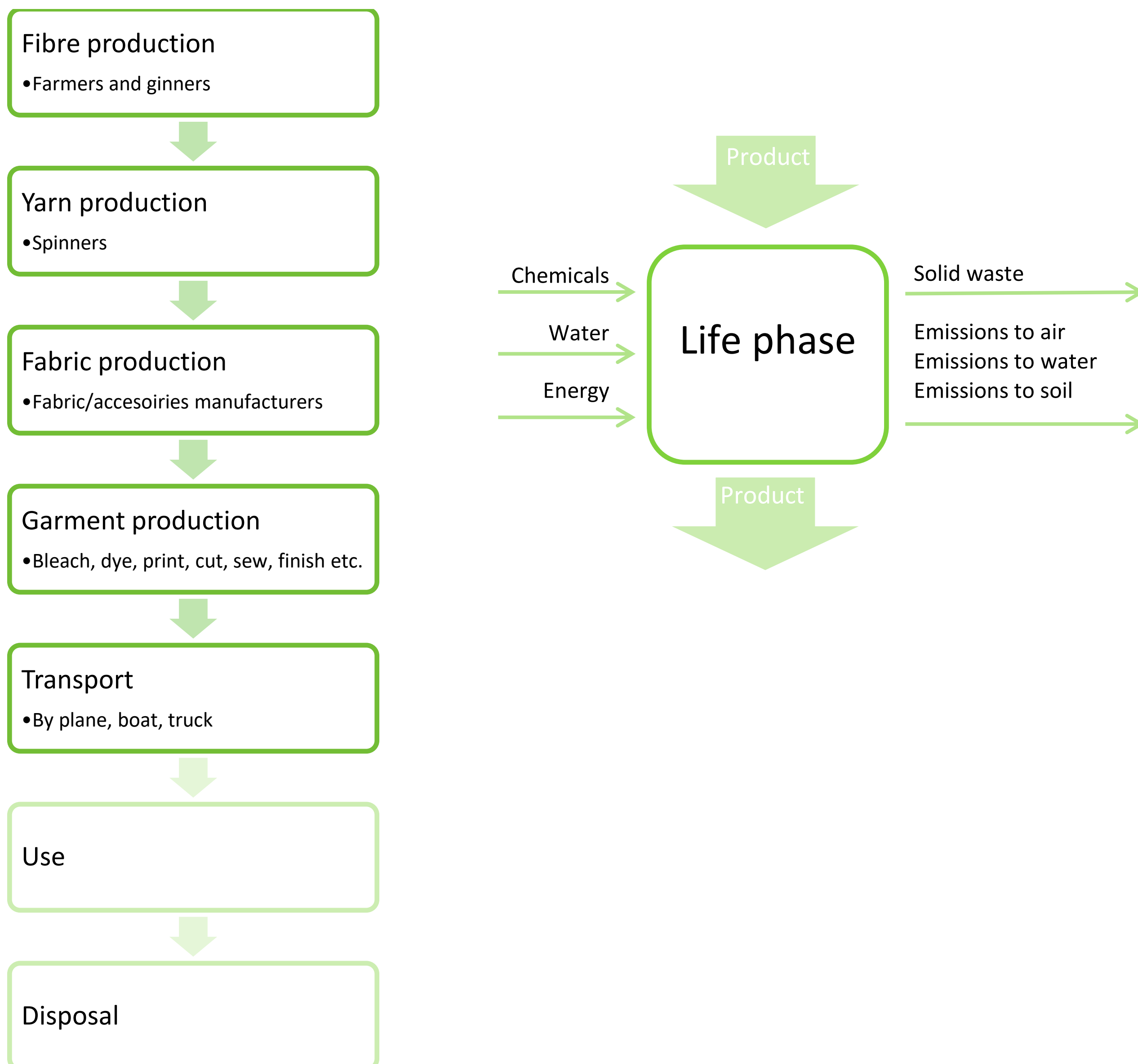


Figure 8. Initial flowchart for LCA for garments and in- and outputs that are modelled for each life cycle phase

3.3 Data collection and LCA software

Now that the goal of the research is set and the details of the product system are determined, it is more clear which information is needed to perform the LCA and which can be left out. As figure 8 indicates, for every piece of garment, only the foreground processes will be measured and for each phase of the supply chain the following information is needed: how much product (e.g. cotton fibre) goes in and how much product comes out of the phase (e.g. cotton fabric), the input, divided into chemicals, energy and water and the output, divided into solid waste and emissions to air, water and soil.

3.3.1 Surveys and Databases

In order to get the information that is needed to fill in the flows in the LCA, the information is collected directly from the supplier and factories that produce the garment of choice. Because WE Fashion has direct contact with the ready-made garment suppliers, these are contacted first. The factories that they own are closest to the finished product, so they produce complete garments and are at the end of the supply chain. Because presumably the most information can be found here, the first survey contains the processes that are typically found in the garment production phase and the fabric production phase of the supply chain. The garment producers first receive a survey where they can fill in which processes are performed in-house and which are subcontracted as well as a survey that asks which parts of the product they produce. This is not relevant for a cotton t-shirt, as it only made up from main material, but jeans contain buttons, lining etc. so it is expected that more subcontractors will be involved there.

At the same time, the garment suppliers receive a survey about the other life phases of the product, like cotton cultivation and spinning, where the country of origin is asked, as well as the contact details of the person responsible for this step, in order to get further down the supply chain. The survey for the in-house and outsourced processes can be found in Appendix 2 and the survey for other life phases can be found in Appendix 3. Both are the templates for the jeans. The survey for the t-shirt is the same but less expanded as it only consists of main material. When these surveys are returned, the actual survey is designed based on which processes are performed by the contacted person. For example, a separate survey is send to cotton fibre producer, which focuses on the cultivation of cotton and asks which inputs and outputs are involved in this. For every process that a producer performs, they can fill in what the inputs and outputs of this phase are so that these can be modelled in the LCA software.

For the information that cannot be retrieved through surveys, database information is needed. There can be several reasons that information is not obtainable through surveys. Downstream, on the consumer side, no surveys will be used, so here database information combined with the specifics for these products are used. Upstream, the reasons may vary. Firstly, it might be hard to find the right contact person for each process and even if this person is found, the further away they are from WE Fashion, the less inclined they might be to cooperate. Secondly, the language barrier makes it hard to communicate. Direct garment suppliers can be big, international companies with large teams and sometimes even their own CSR department, but a small cotton farmer in China likely does not speak English. Thirdly, some producers do not want to share the exact composition and volume of the chemicals they use due to sensitivity of the data or competition. These issues can be worked around by being clear on the intended purpose of the survey and asking the garments suppliers for help in reaching their suppliers and translating the data.

Where database information is still required, the most true to life information is used. Which means that it has to be information from the right country, from a scenario that is similar to that of the sampled garment and fitted to the right amounts. All information that retrieved through databases or estimated using other sources is labelled in the results to keep the research as transparent as possible. This is mainly true for the transport, use and disposal phases. It would be better to have empirical data on these phases as well, but in regard to the research goal, the phases that might more easily be influenced by the focal company have priority. Table 4 and 5 displays the sources of all used information. In Annex 4, the sources and assumptions are more thoroughly explained.

Life cycle phase	**Data type**	**Source**	**Country**
Cotton cultivation	Cradle to gate, including ginning at farm	Database information included in GaBi on cotton production in US	Turkey
Spinning	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Knitting	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Preparing and cutting	Source of materials, input and outputs allocated to this product	Survey results	Turkey
Sewing	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Bleaching	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Dyeing	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Printing	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Finishing	Source of materials, input and outputs allocated to this product	Did not receive results	Turkey
Laundry	Source of materials, input and outputs allocated to this product	GaBi database information on US transport per boat. Estimated distance from address to address:	Turkey
Transport	Energy, water and detergent use as well as outputs	GaBi database information on transport per truck. Estimated distance from address to address: 2976 km.	Turkey – The Netherlands
Use	Worn for 100 days, washed every 3 days	Zygmunt & Walker, 2008	The Netherlands
Disposal		Database information and estimation	The Netherlands

Table 4. Data sources for various processes t-shirt

Life cycle phase	Data type	Source	Country
Cotton cultivation	Cradle to gate, including ginning at farm	EcoInvent database v.2.2 on cotton cultivation in China.	China
Spinning	Source of materials, input and outputs allocated to this product	Database information and estimation	China
Weaving	Source of materials, input and outputs allocated to this product	EcoInvent database v.2.2	Bangladesh
Preparing and cutting	Source of materials, input and outputs allocated to this product	Survey results	Bangladesh
Sewing	Source of materials, input and outputs allocated to this product	Survey results	Bangladesh
Bleaching	Source of materials, input and outputs allocated to this product	Survey results	Bangladesh
Dyeing	Source of materials, input and outputs allocated to this product	Database information and estimation	Bangladesh
Printing	Source of materials, input and outputs allocated to this product	Survey results	Bangladesh
Finishing	Source of materials, input and outputs allocated to this product	Survey results	Bangladesh
Laundry	Source of materials, input and outputs allocated to this product	Surveys results	Bangladesh
Transport	Energy, water and detergent use as well as outputs	GaBi database information on US transport per boat. Estimated distance from address to address: 13.792 km.	Bangladesh – The Netherlands
Use	Worn for 365 days, washed every 7 days	Zygmunt & Walker, 2008	The Netherlands
Disposal		Database information and estimation	The Netherlands

Table 5. Data sources for various processes jeans

3.3.2. Life Cycle Assessment software

It is possible to model the impact assessment by hand, but it is a lot more time and work intensive as well as prone to error than using a modelling software. Also, there is no need to reinvent the wheel, as most LCA software is very elaborate and detailed and can generally do more than a person by hand. The most widely available and most used software programs that can be used for holistic life cycle research are OpenLCA, SimaPro and GaBi.

OpenLCA is a free modelling software that was designed as a fast and widely available framework for life cycle assessment, that can be used and complemented by everyone. It is capable of handling both simple and complex models and is mainly known for its flexibility and transparency. Because the source code is open, people can improve it themselves which makes for a wide range of options if you are experienced in the field of LCA. This is also the downside, as the program is not easy to get into if you are a beginner and it could be more user friendly. Additionally, it does not include much build-in database information and therefore needs a lot of external databases that are not open access like the program itself.

SimaPro is a life cycle assessment software that is most used in academic contexts. It is a very user-friendly software that is both highly flexible and transparent in its calculations. This software keeps a good overview of the choices and assumptions that are made and it has various options for displaying the results of the impact assessment. SimaPro requires a license, even for academic use and it therefore less widely available, furthermore it requires operating system Windows to run.

In this case the LCA software GaBi is used. It is one of the most used LCA software available and its extensive modelling options and built-in database make it very suitable for the purpose of this research. GaBi is freely available when using an educational license and an extensive handbook on how to use it can be found on their website. It is found that is terms of calculated results, GaBi and SimaPro are practically identical (Herrman & Moltesen, 2015) GaBi is however a little limited in displaying the results compared to SimaPro.

Below is an overview of the user friendliness, possibilities and price of the three products. OpenLCA is not very user friendly, as the user interface is very limited and its open source makes the program hard to understand for beginners. When you are familiar with the program however it has many possibilities and as it is free, the price is very good. SimaPro is the best software out of the three in terms of user friendliness and possibilities but it is expensive and therefore not viable for a company that wants to explore LCA. GaBi performs moderately in user friendliness as it can be unclear where to find certain options, but it comes with an extensive handbook. It is also okay in terms of possibilities, but could use some more options for displaying graphs. The price is good because an educational license is free. However for a company, it is still quite expensive.

Program	User friendly	Possibilities	Price
OpenLCA	-	++	++
SimaPro	++	++	-
GaBi	+	+	+

Table 6. Comparing LCA software programs

4. Inventory analysis

4.1 Preparing the inventory analysis

4.1.1 Constructing a flowchart

The inventory analysis builds on the goal and scope definition by forming a model of the data that is collected. This model is called a flow model and it shows the system boundaries, so where the system starts and where it ends as well as all relevant in- and outputs. What you end up with is a flowchart of everything you are going to measure and analyze. Where in the goal and scope definition an initial flowchart is created in order to define the system boundaries, in the inventory analysis this flowchart needs to be developed to show in detail which activities are included and how these activities relate by depicting the flows. This flowchart can be made by hand, but it is much easier to model through GaBi because the software already asks for the relevant inputs and outputs like energy. Therefore the flowcharts in figure 9 and 10 are made with GaBi.

For the t-shirt the life cycle from cradle to factory gate takes place in Turkey. First the cotton is grown, then it is spun and knitted into jersey fabric. The fabric is then bleached and dyed. Then the fabric is printed, prepared, cut and sewn into a garment. The garment is finished and laundered before being transported to the Netherlands by truck. In the Netherlands it is worn and discarded.

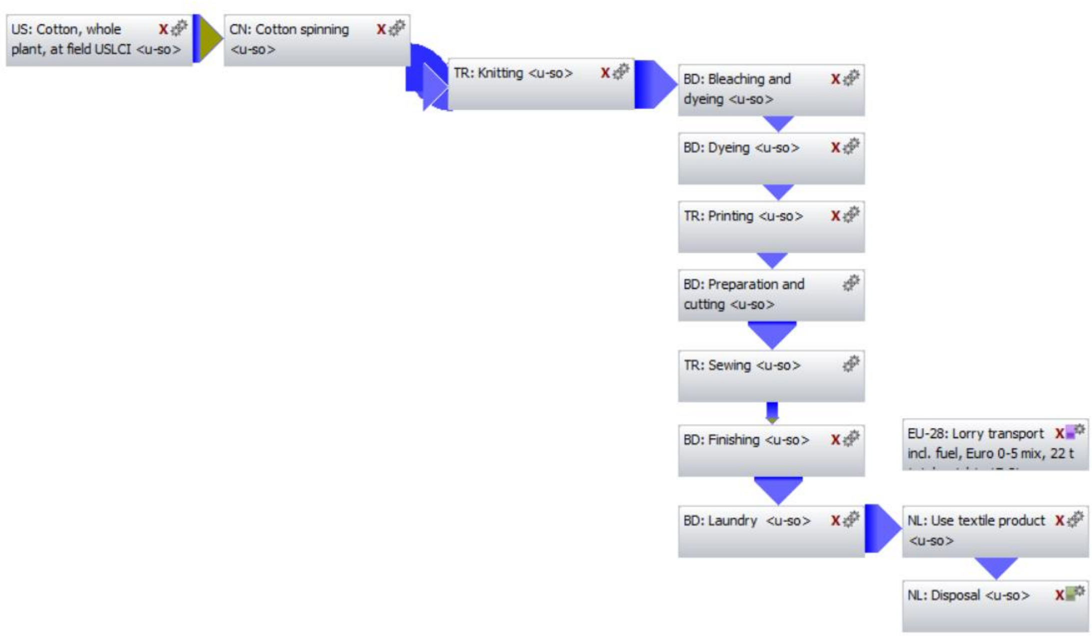


Figure 9. Flowchart created in GaBi for the men's t-shirt

The flowchart for the jeans is as follows. First the cotton and elastane are produced in China. They are spun together and woven into a fabric, also in China. In Bangladesh, the wet processing phases are performed, including bleaching, preparation and cutting, sewing, the adding of the other parts, finishing and laundry are performed by the main factory that is in contact with WE Fashion.

Dyeing is performed by other factory, as well as the production of the lining, plastic buttons, metal parts, elastic band and faux leather which are all done by separate manufacturers. When assembled, the garment is transported from Bangladesh to the Netherlands by boat, which is approximately 12000 km and then the garment is used in the Netherlands. It is assumed that the jeans are only washed but not tumble dried or ironed for about 156 times (every 7 days for a year) before they are discarded through land filling.

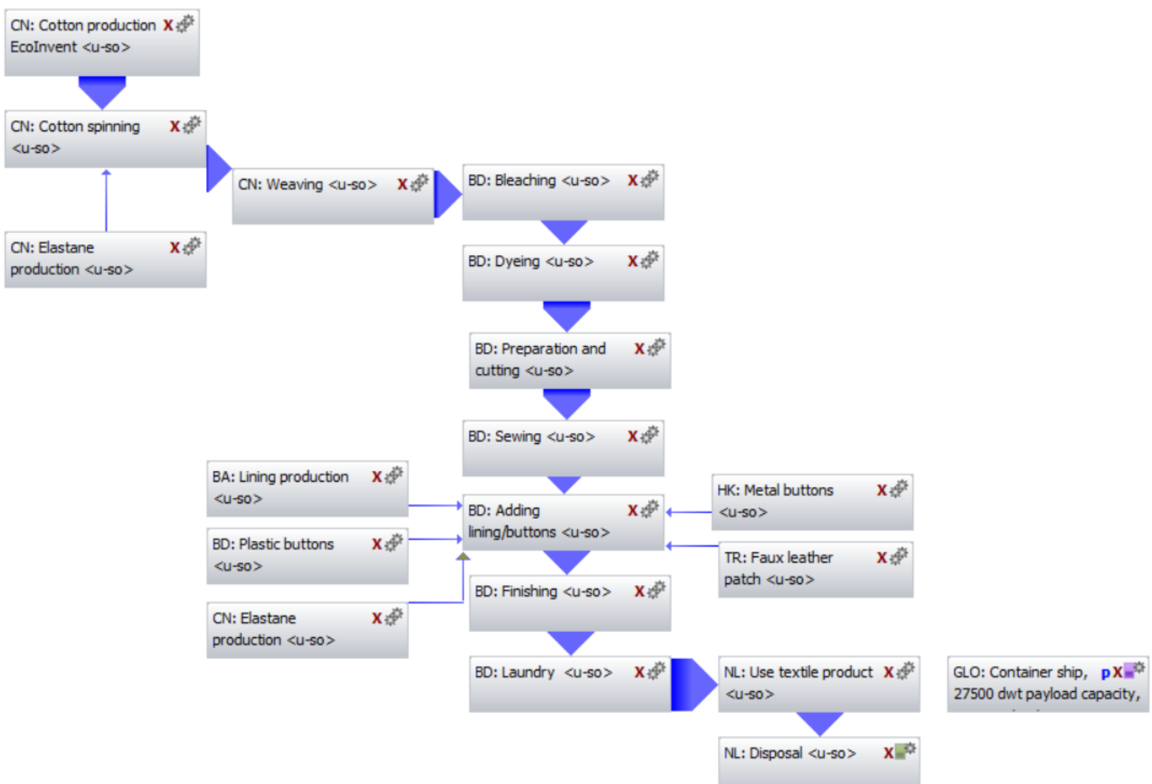


Figure 10. Flowchart created in GaBi for the boy's jeans

4.1.2. Data collection

The data collection forms the body of knowledge which is to be assessed. It is therefore very important to consider which information is needed. Basically it is about collecting the information that will complete the flow chart. This means collecting numerical as well as qualitative data on the inputs, processes and outputs in each phase of the life cycle. Inputs can consist of raw materials, energy or physical inputs like land use, then products can be used and outputs are divided between emissions to air, water and soil (Baumann & Tillman, 2004).

The collection of the data is the trickiest part of the LCA. Because WE Fashion doesn't produce their own clothes and doesn't own any factories, the information needed has to come from the suppliers with whom it collaborates. At least for the production phase, the information needed will therefore be collected though personal contact with suppliers. They give their own data, that represents their factory. For information lower down the supply chain, personal contact and direct information are aimed for as well, through the suppliers who have their own suppliers. The surveys that are used for data collection can be found in appendix 2. However, not all information can be won through surveys. Reasons for this include sensitivity of the data, translation issues or just lack of knowledge in suppliers and producers. In this case, some information is supplemented with database information, like EcoInvent. For downstream processes, data can be collected from costumers and waste management companies directly, or also through EcoInvent. Which exact data comes from which source can be found in appendix 4.

4.1.3 Calculating the environmental load

Allocating the right attributes to certain parts of the life cycle starts here and to protect the validity and reliability of the research descriptive data is needed. Choices should be well documented and explained, because otherwise you risk the research becoming too subjective (Baumann & Tillman, 2004). Five steps are needed in order to properly calculate. First, data needs to be normalized, in order to be comparable. In- and outputs are delivered in different units so they need to be calculated in order to fit the functional unit, in this case **one men's t-shirt, worn for 100 days** and **one pair of boy's jeans, worn for 356 days.** In the model this means that the unit that is used is the weight of one selected article of clothing, which differs for the different pieces of clothing. Secondly, the flows that are linked to activities need to be calculated in order to make up the mass balances, by setting up relationships between inflows and outflows. This should also be based on the functional unit.

But not only flows within the systems boundaries are calculated, the ones coming in and leaving as well. Then the inputs and outputs of the whole system are summed up (Baumann & Tillman, 2004). In this case, the data that is asked from the suppliers is already adapted to be allocated to a specific phase and product and the asked for data is delivered in a unit/kg fibre, fabric or garment. The data can then be calculated to fit the weight of the product. For the cotton t-shirt, this is just the weight of the whole t-shirt, but for the jeans, separate weights are needed for the main material, lining, buttons etc. Below in table 7 and 8 are the specific weights of the products.

Product part	Calculation weight	Actual weight	Calculation factor
Main material	1000 g (1 kg)	120,96 g	/8,26719577

Table 7. Calculation weight, actual weight and calculation factor for the men's t-shirt size M

Product part	Calculation weight	Actual weight	Calculation factor
Main material	1000 g (1 kg)	404,45 g	/2,47249351
Lining	1000 g (1 kg)	22,41 g	/44,6229362
Metal buttons	1000 g (1 kg)	9,06 g	/110,375276
Plastic buttons	1000 g (1 kg)	0,9 g	/1111,11111
Elastic band	1000 g (1 kg)	4,51 g	/221,72949

Faux leather patch	1000 g (1 kg)	1,66 g	/602,409639
Total weight	**1000 g (1 kg)**	**442,99**	**/2,2573873**

Table 8. Calculation weight, actual weight and calculation factor for the boy's jeans size 158

4.2 Inventory results

The life cycle inventory gives an overviews of all input and outputs that are relevant for processes in the life cycle. The results are typically presented in a table. In this case, the results are already calculated to fit the functional unit. For instance, for the Men's -shirt, we know that one t-shirt weighs 120,96 g. The data received gives information about 1 kg fabric. An example of the calculation, in this case for water input, therefore is as follows:

$$\frac{Received\ data\ for\ 1\ kg\ fabric}{Calculation\ factor}\frac{60L}{8{,}26719577} = 7{,}26\ L$$

Table 9 and 10 show the life cycle inventory for the t-shirt and the jeans respectively.

Phase	Water in	Energy in	Chemicals in	Garment out	Water out	Solid waste out	Chem out
Fibre production and ginning	28,60 L	0,60 MJ	(too much to put in from database)	120,96 g	0,30L	N/A	(Too much ")
Spinning	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Knitting	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Preparation and cutting	7,26 L	0,004 kWh	Textile chemical: 0,006 g	120,96 g	0,02 m^3	0,02 kg	N/A
Sewing	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Bleaching	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Dyeing	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Finishing	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Laundry	Not found	Not found	Not found	Not found	Not found	Not found	Not found
Transport							
Use	0,87 L	0,02 kWh/kg	Washing powder	120,96g	3,19 L/kg	N/A	N/A
Disposal	N/A	N/A	N/A	120,96 g	N/A	N/A	N/A

Table 9. Life Cycle Inventory Analysis for men's t-shirt

Phase	Water in	Energy in	Chemicals in	Garment out	Water out	Solid waste out	Chem out
Fibre production and ginning	95,62 L	1,99 MJ	(too much to put in from database)	404,45 g	1 L	N/A	(too much ")
Spinning	2,2 L	0,6 MJ	N/A	404,45	N/A	N/A	N/A
Knitting	20,99 L	31,24 MJ	(too much to put in from database)	404,45 g	18,48 L	56,91 g	(too much ")
Preparation and cutting	0,19 L	0,008 kWh	N/A	404, 45 g	0,19 L	N/A	N/A
Bleaching	0,51 L	4,28 kWh	Bleach - 65%: 4, 04 g Hydrogen Peroxide: 4,15 g GW 704 S: 0,51 ml Caustic Soda: 0,91 ml Denimcol Pex: 0,81 g Softifinish PE: 2,83 ml Lava Fast CNC: 8,09 ml Citric acid: 0,51 g	404,45 g	0,51 L	N/A	N/A
Dyeing	Not received	Not received	Not received	Not received	Not received	Not received	Not received
Sewing	13,10 L	0,18 kWh	N/A	404,45 g	13,10 L	N/A	N/A
Added lining	N/A	N/A	N/A	442,99 g	N/A	N/A	N/A
Finishing	1,16 L	0,04 kWh	N/A	442,99 g	1,16 L	N/A	N/A
Laundry	48,73 L	0,36 kWh	GW 704 S: 5,27 g Enzyme: 5,27 g Bleach: 78,85 g Denimcol-PEX: 1,05 g Softener: 10,55 g	442,99 g	48,73 L	N/A	N/A
Transport	N/A	61,3 L diesel	N/A	442,99 g	N/A	N/A	N/A
Use	3,19 L/kg	0,08 kWh/kg	Washing powder	442,99 g	3,19 L/kg	N/A	N/A
Disposal	N/A	N/A	N/A	442,99 g	N/A	N/A	N/A

Table 10. Life Cycle Inventory Analysis for boy's jeans

4.3 Summary and interpretation

4.3.1 Men's t-shirt

Unfortunately not many results have been found for the inventory assessment of the men's t-shirt. The only phase the survey has yielded any results for is cutting and sewing. For the rest of the information, the producers have declared not to have access to the information, not to be able to share it due to confidentiality or they did not respond at all. It might be possible to replace the rest of the phases with database information, but this would require assumptions on every aspect of the modeling, including the types and amounts of inputs and outputs. This would results is very unreliable and general information that isn't very usable for WE Fashion.

Therefore, the men's t-shirt will not be discussed in the results any further and the rest of the research will focus on the boy's jeans.

4.3.2. Boy's jeans

Looking at table 9 a few results stands out. Firstly, within the supply chain water use as well as chemical in and output are largest in the cotton cultivation phase. This is expected, as cotton cultivation is known for its large water use as well as fertilizer and pesticide use. But because this information is obtained through database information it is uncertain how much this correlates with the situation of the specific jeans. The data for the wet processing is obtained through surveys and here the water usage, as well as waste water output, is biggest for the laundry process. Energy use however is bigger for the bleaching process. Note that there are no results from the surveys on solid waste and most of the chemical inputs Whether this means that no chemicals are used or that the producer is not aware of what chemicals are used is unknown, but because databases yield so many results for chemical input in the weaving phase, it is unlikely that nothing is added during for instance preparation and cutting. For solid waste, the results are also highly unlikely because most processes aren't 100% material efficient and at least some of the fibre and fabric should be lost, especially in the cutting phase.

Without applying the data to certain impact categories, it seems like the laundry phase had the most impact of all wet processes, as it requires the largest volume of water, as well as larger quantities of chemicals than the bleaching phase and the most waste water comes out as well. This seems counterintuitive because it would make more sense for a bleaching phase to require large quantities of bleach, than a laundry phase. In this case this can mean that within the factory the processes aren't precisely linear or that the fabric and garment both go through a separate bleaching phase. In addition, it is expected that the dying phase would have an even bigger input of chemicals, but this information is not received yet.

For the use and discard phases information is based on the average water and energy use for a washing machine in the Netherlands. The care label in the product says that the jeans can only be washed, not tumble dried which makes more relevant modelling. In reality there is a big difference in how costumers care for their clothes and some people will still tumble-dry the jeans, which makes the impact of the use phase higher. A company cannot do much to improve the environmental impact that occurs in the use phase, other than adjusting the care label to only include the absolutely necessary care. For example tumble-drying should not be recommended if it is not absolutely necessary. The two products should only be washed and therefore have minimal care requirements already.

In the following chapter, the inputs and outputs will be measured in terms of an environmental potential. This gives the data another meaning and can link certain steps to environmental issues.

5. Life cycle assessment

The impact assessment part of the LCA translates the values from the inventory into environmental impact categories. Some of the information might not seem relevant immediately, but gets another meaning when looked at as for example a potential for acidification. Which data belongs to which impact category is already established and can be translated according to the book by Tillman and Baumann (2004). In order to do an impact assessment you first have to classify the data according to environmental impact, then you have to characterize the different data that all contribute to the same environmental impact (like CO_2 and CH_4, which both contribute to climate change) so that you get a weighting result.

In the classification of the data, different chemicals that contribute to the same impact categories are identified. Classification is based on set, scientific data. For instance, it is researched that both CO_2 and CH_4 contribute to global warming. But every kg of CH_4 emitted, does as much damage as 21 kg CO_2 in a period of 100 years. Because global warming potential is measured in CO_2-equivalent, it is describes as CH_4 has a CO_2-equavalent of 21, or 21 100-years GWP.

When the right factor is knows through classification, the characterization stage multiplies the actual data with these factors in order to get the result in terms of a potential. For instance, if 3 kg CH_4 is used, the actual Global Warming potential is 3*25 = 75 kg CO_2 equivalent. In this research, the characterization will be performed in GaBi and will not be calculated separately. Below, each impact category is shortly explained and the classification is discussed. The impact categories are global warming potential, eutrophication potential/nutrient enrichment, ozone depletion potential, acidification, ecotoxicity, human toxicity, water use, resource consumption/abiotic depletion. Some chemicals contribute to several different impact categories, like NO_x, which can contribute to human toxicity, ecotoxicity and eutrophication. Figure 11 shows and example of how classification and characterization works. CO_2 and CH_4 for instance contribute to the greenhouse effect and have a global warming potential.

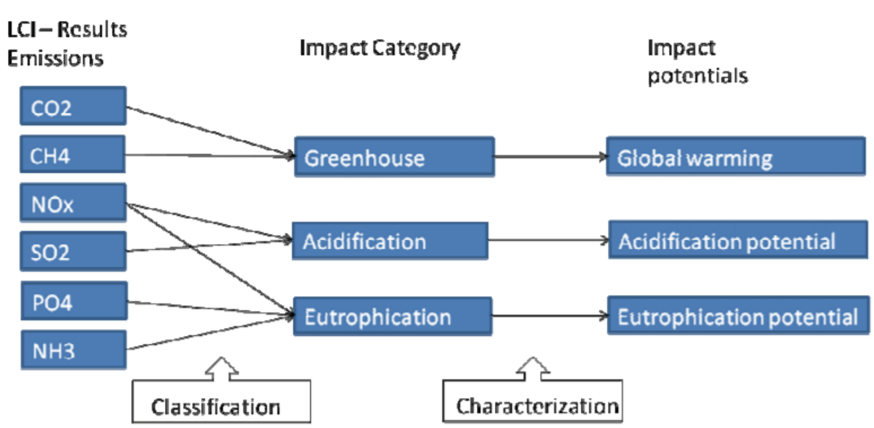


Figure 11. Visualization of classification and characterization (vanDuinen & Deisl, 2009)

5.1 Impact Categories and Classification

5.1.1 Global warming potential (GWP)

The greenhouse effect is the phenomenon where an increasing amount of short wave radiation is caught within the atmosphere of earth. This leads to an increase in the average temperature among other changing weather conditions, which is called global warming. While this greenhouse effect is naturally occurring, it is being sped up by human activity (Baumann & Tillman, 2004). Several chemicals contribute to global warming, including CO_2 and CH_4. These can be measured in the ratio between increased infrared absorption of a certain chemical and the increased infrared absorption of CO_2 and is expressed in CO_2 equivalent. Which, as mentioned above leads to CH_4 having a GWP-100 of 21. While it can also be measures over 20 or 500 years, 100 is the most common (GaBi, 2017). Figure 12.1. shows how the greenhouse effect works and some of the chemicals that have global warming potential and figure 12.2 shows a table of all chemicals with global warming potential and their equivalent.

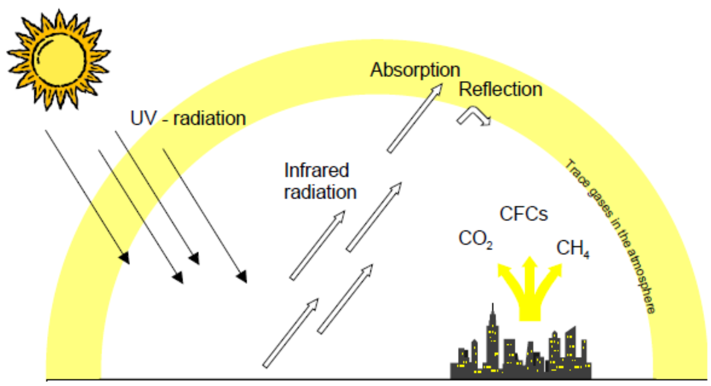


Figure 12.1. The greenhouse effect, which leads to global warming (GaBi, 2017).

Trace gas	GWP 100 in kg CO_2-eqv. /kg
CO_2	1
CH_4	21
1,1,1-trichloroethylene	110
CCl_4	1400
N_2O	310
SF_6	163000
CF_4	4400

Figure 12.2 Global warming potential of different chemicals (Baumann & Tillman, 2004).

5.1.2 Eutrophication potential (EP)

Eutrophication is excessive enrichment of the soil. It means that soil, or water is enriched with nutrients. In water it can lead to excessive algae growth and in soil to unwanted plants and pests spreading. In many cases the oxygen is took from the environment. Nitrate is often involved in this reaction and when it reacts into nitrite it can also be lethal for humans (GaBi, 2017). This phenomenon is often caused by extensive fertilizer use like nitrogen and phosphorus, which cotton cultivation is also known for. Eutrophication potential is measured in PO^3_4 equivalent (Baumann & Tillman, 2004). Figure 13.1 shows the eutrophication potential and some of the chemicals involved and figure 13.2 shows the table with the relevant chemicals.

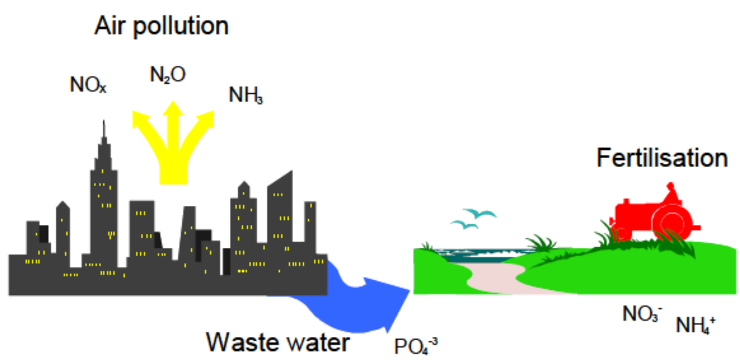


Figure 13.1. Visualization of the eutrophication potential (GaBi, 2017)

Substance	EP in g PO_4^3-eqv. / g
PO_4^3	1
H_3PO_4	0,97
P	3,06
NO_x	0,13
NH_3	0,35
NH^+_4	0,33
NO^-_3	0,1

Figure 13.2. Eutrophication potential of different chemicals (Baumann & Tillman, 2004).

5.1.3 Ozone depletion potential (ODP)

Ozone (O_3) is a substance that is found mainly in the upper stratosphere. While it is highly polluting and damaging for human and ecosystem health in the lower atmosphere, in the stratosphere it plays a crucial role in blocking harmful ultraviolet radiation from the sun by absorbing short wave radiation and releasing it as long wave radiation, which is less harmful (Baumann and Tillman, 2004). Chlorine-hydrocarbons and nitrogen oxides, which are exhausted by human activity react with ozone, which thins the layer and has created what is called the hole in the ozone layer. If more short wave UV radiation is let through, this can harm both humans, crops, plankton and so on (GaBi, 2017). Figure 14.1 shows a visualization of ozone depletion, while figure 14.2 gives a table of the chemicals that contribute to ozone depletion.

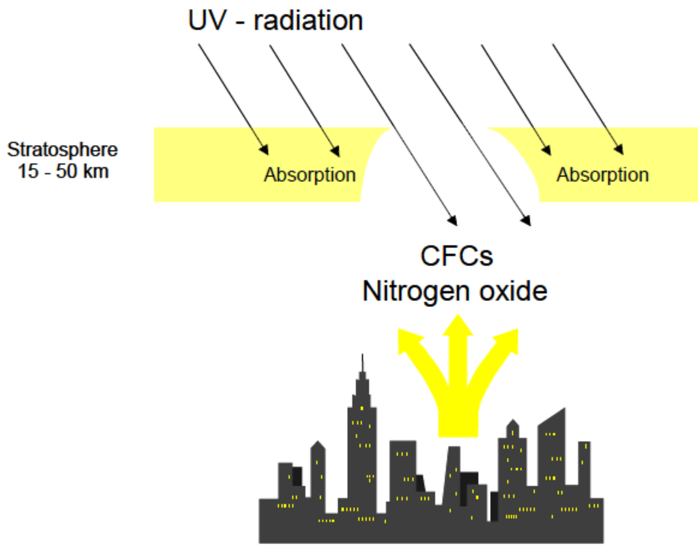


Figure 14.1. Visualization of Ozone depletion potential (GaBi, 2017)

Substance	ODP in kg CFC-11 / kg
CFC-11	1
CFC12	0,82
CFC-113	0,9
CFC-114	0,85
Hcfc-22	0,034
Halon 1201	1,4
CCl_4	1,2

Figure 14.2. Ozone depletion potential (Baumann & Tillman, 2004)

5.1.4 Acidification potential (AP)

When the pH value of the soil or water drops below 5,6 we speak of acidification, which is most well knows for the phenomenon acid rain. Directly, this can affect both nature and human structures by dissolving and corroding them. Indirectly, it changes the soil and causes nutrient wash out and metal solubility (GaBi, 2017). Acidifying pollutants produce H^+ ions and the acidification potential is measured as the number of H^+ ions per kg substance relative to SO_2 (Baumann & Tillman, 2004). It is measured in SO_2 equivalent. Figure 15.1 shows the process of acidification and figure 15.2 is the table with substances that have acidification potential.

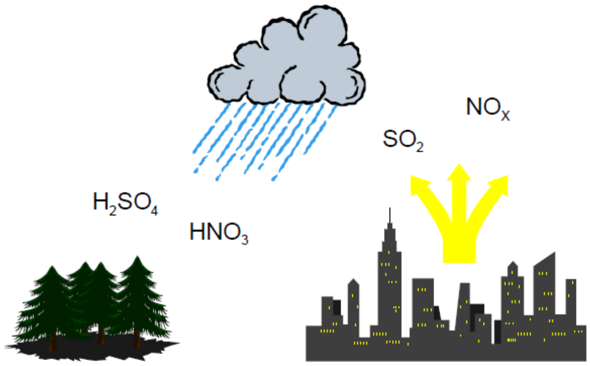


Figure 15.1. Visualization of the acidification potential (GaBi, 2017)

Substance	AP in SO_2-equivalent / g
SO_2	1
HCl	0,88
HF	1,60
NO_x	0,7
NH_3	1,88

Figure 15.2. Acidification potential (Baumann & Tillman, 2004)

5.1.5 Ecotoxicity and human toxicity

Ecotoxicity and human toxicity are less straight forward than global warming and eutrophication potential as they are more diverse. Table 3 also showed that there is no international consensus on the characterization of these impacts either. Basically, the ecotoxicity potential measures the negative impacts on ecosystems, while the human toxicity potential measures negative impacts on human lives but these can also be connected and lead to other impacts. Within GaBi, an extensive method is used to measure both. Figure 16.1 and 16.2 show the different ecotoxicity and human toxicity potential environments.

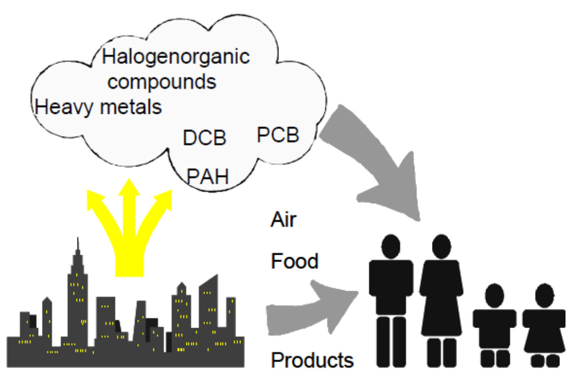


Figure 16.1 Human toxicity potential (GaBi, 2017)

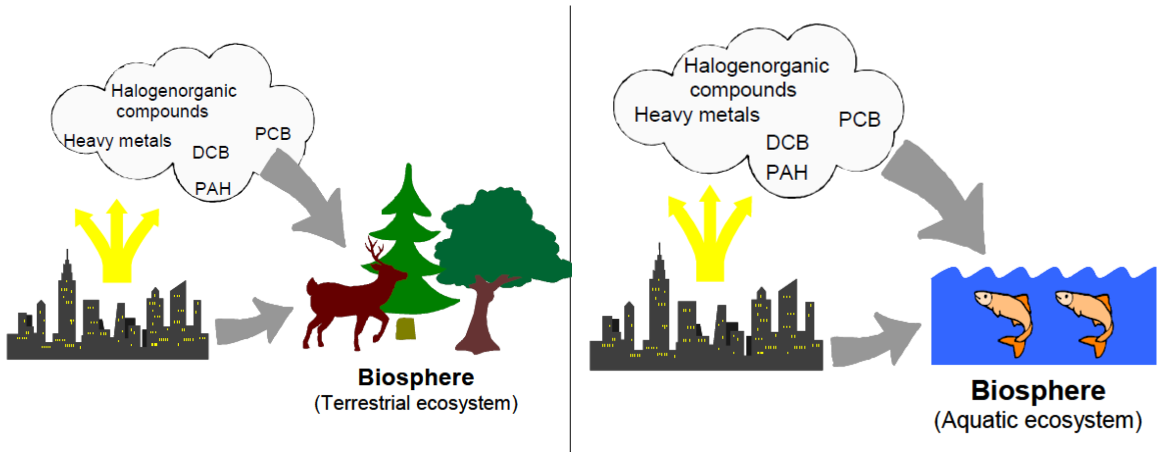


Figure 16.2. Ecotoxicity potential, divided between the terrestrial ecosystem and the aquatic ecosystem (GaBi, 2017)

5.1.6 Water use

Water use is an important impact category linked to the clothing industry because so much water is needed for cotton cultivation and wet processing. What the exact impact is depends on the source of the water and the region. Rather than displaying a potential linked to certain chemicals, water use can be displayed as the volume of water that is needed in m^3 or liters (Baumann & Tillman, 2004).

5.1.7 Abiotic depletion potential / resource use

Abiotic depletion potential measures the use of natural resources like oil, coal and other ores. It only measures non-living, non-renewable resources and is therefore mostly applicable to energy use in the clothing industry and to man-made fibres (Baumann & Tillman, 2004). Figure 17 contains a number of substances that are measured under abiotic depletion potential, which are measured in antimony; Sb-equivalent.

Substance	Static reserve life (years) in Sb-equivalent
Aluminium	1×10^{-8} kg
Iron	$8{,}43 \times 10^{-8}$ kg
Crude oil	0,0201 kg
Natural gas	0,0187 kg
Fossil energy	$4{,}81 \times 10^{-4}$ kg

Figure 17. Substances that contribute to the abiotic depletion potential (Baumann & Tillman, 2004).

5.2 Characterization

The characterization of the results is done using GaBi using International Reference Life Cycle Data System (ILCD) recommendations by the European platform on Life Cycle Assessment. In the characterization, the life cycle is separated into four phases, the fabric production phase, including raw material production, spinning and weaving or knitting. The second phase is wet processing, including bleaching, dyeing, printing, finishing and laundry. Transport is measures separately. Then the use phase and lastly the disposal phase.

5.2.1 Global warming potential

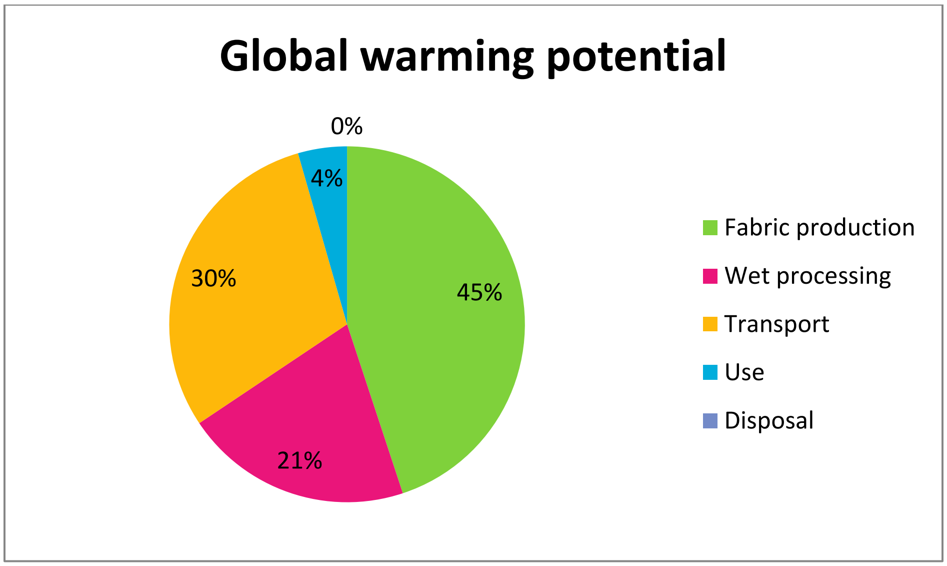


Figure 18. Characterization of Global Warming Potential for the jeans' life cycle

The characterization shows that fabric production makes up the biggest share of the global warming potential with 45%. Hackett (2015) also finds that fibre cultivation and fabric assembly together have the largest influence on global warming. It is not completely clear why this is. It might be that a lot of fossil fuels are needed to process the cotton from plant to fabric. Transport follows swift, which is to be expected due to the assumption that the boat uses diesel to propel and diesel is a fossil fuel. Wet processing also contributes a considerable share, while use makes op only 4% of the total impact. The disposal phase does not contribute to the global warming potential.

5.2.2 Eutrophication potential

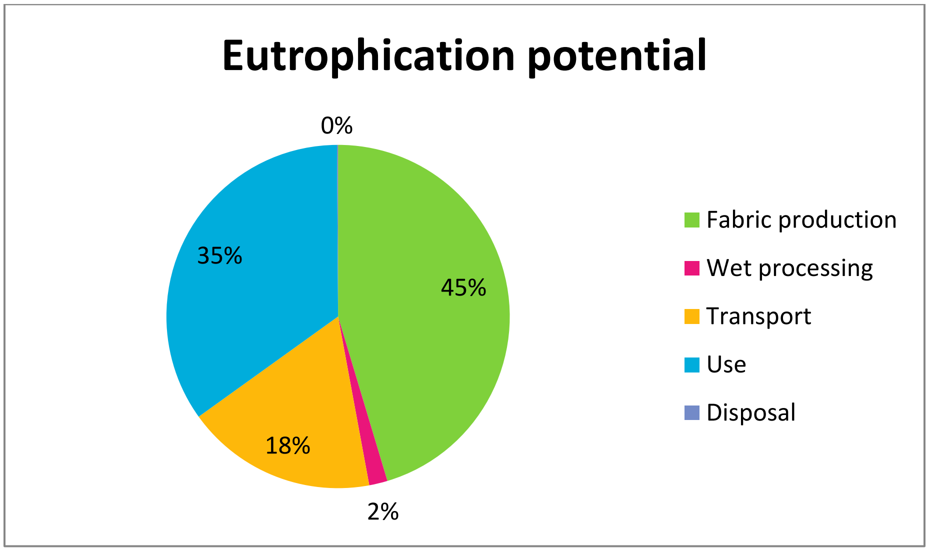


Figure 19. Characterization of Eutrophication Potential for the jeans' life cycle

The graph on eutrophication potential above shows the average shares for terrestrial, marine and fresh water eutrophication. Fabric production has again the biggest impact, for this impact categories this is certainly expected, as cotton cultivation requires large amounts of fertilizers. Because of inefficient irrigation, large amounts of these substances remain in the soil or was out in the ground water and cause eutrophication (Fletcher, 2014). Washing powders are also known for containing phosphorous, which contributes to eutrophication so it makes sense that the use phase also contributes to this phenomenon. Transport makes up 18%, but wet processing and disposal hardly contribute.

5.2.3 Ozone depletion potential

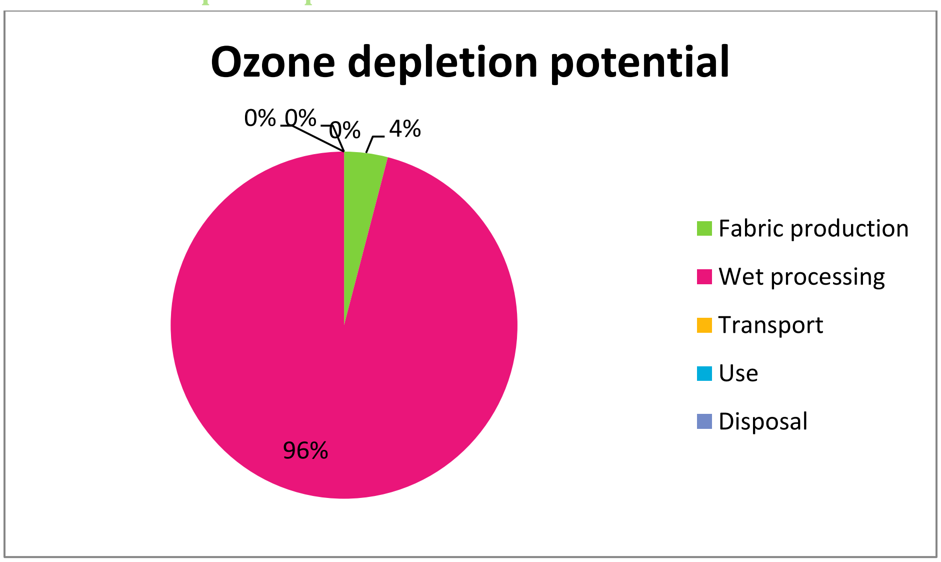


Figure 20. Characterization of Ozone Depletion Potential for the jeans' life cycle

Almost all of the ozone depletion potential is created in the wet processing phases of the life cycle. Substances that contribute to ozone depletion are often volatile and might be used in certain processes like dyeing or laundry. Fabric production contributes about 4 percent to this impact category as well.

5.2.4 Acidification potential

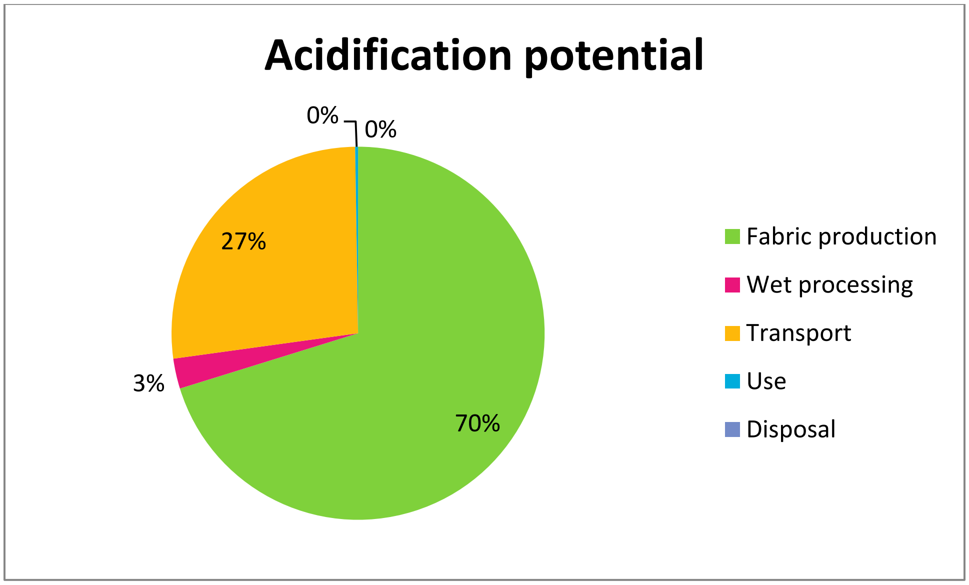


Figure 21. Characterization of Acidification Potential for the jeans' life cycle

The potential for acidification is larges in the fabric production phase. A well as fertilizers, this phase also requires large volumes of pesticides (Fletcher, 2014). These are toxic to pests, but in large amounts they can have a acidic effect on the soil and ground water as well. Especially again in combination with inefficient irrigation systems. Transport also contributes for about one quarter of the impact and a very small share comes from wet processing.

5.2.5 Ecotoxicity and human toxicity

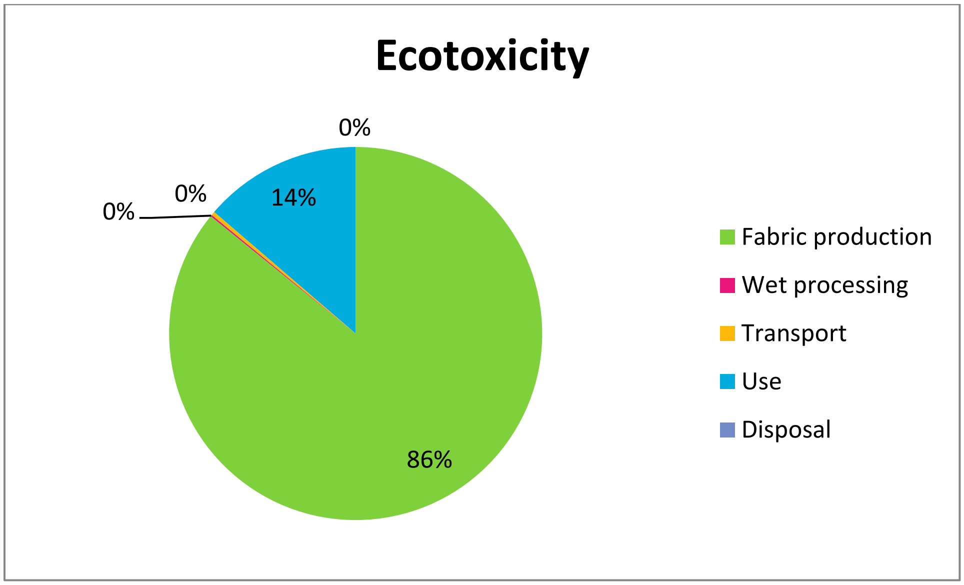


Figure 22. Characterization of Ecotoxicity for the jeans' life cycle

Ecotoxicity in the life cycle almost completely stems from fabric production. Presumably, this is again due to the fertilizers and pesticides that also lead to eutrophication and acidification. These substances dramatically alter the soil which influences both flora and fauna. The use phase also contributes for 14%, most likely because of the use of washing liquids and powders.

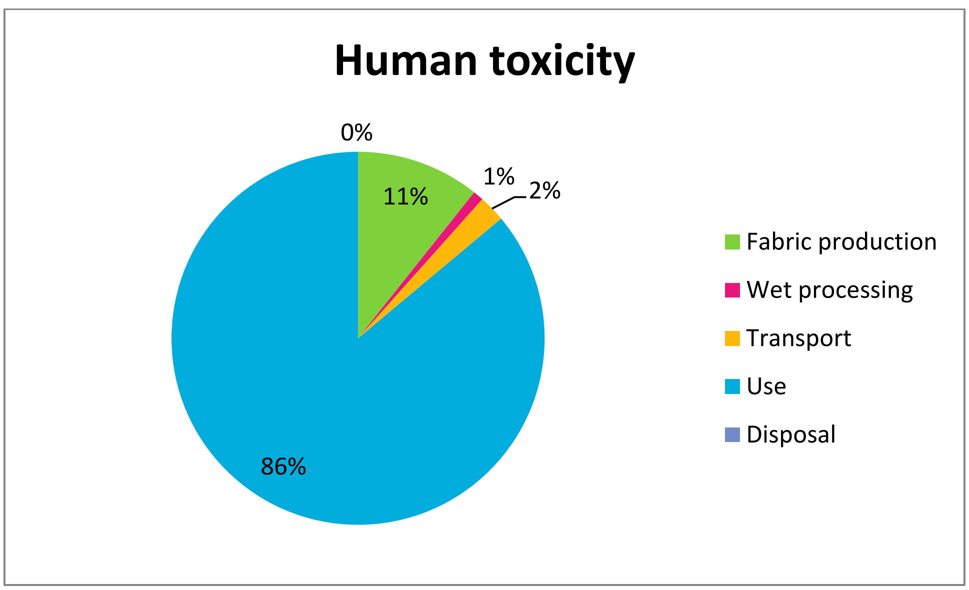


Figure 23. Characterization of Human Toxicity for the jeans' life cycle

Both cancer and non-cancer human toxicity are included in the figure above. The figure for human toxicity is comparable to eco-toxicity but the fabric production phase and the use phase are inverted. 86% of all impact comes from use and 11% comes from fabric production.

5.2.6 Water use

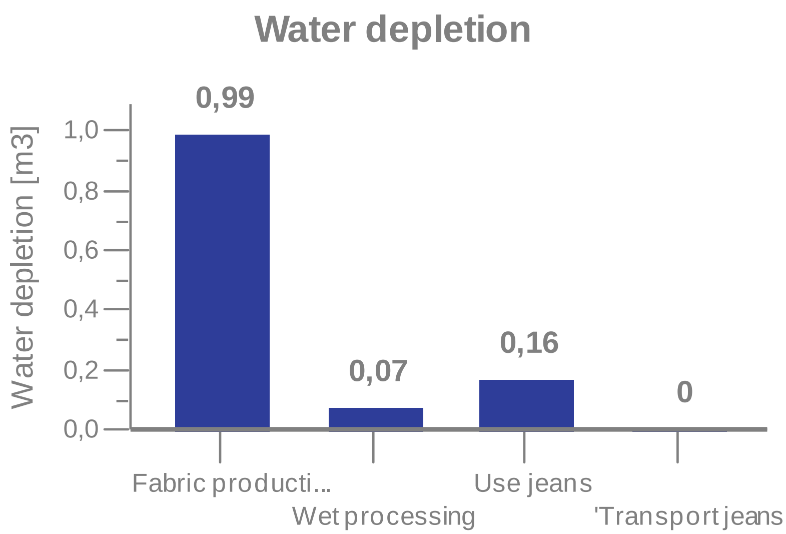


Figure 24. Characterization of Water use for the jeans' life cycle

Water use is biggest in the fabric production phase. This is expected because it is well knows that cotton cultivation requires large amounts of water (Fletcher, 2014). The use phase also contributes for a small part, which is due to the washing of the jeans and the share that wet processing has is actually remarkably small. This seems unlikely, as wet processes uses a lot of water which chemicals like bleach, dyes and washing liquids are added to and they contaminate the water. However, both the researches by Roos et al. (2015) and Hackett (2015) both also show that fabric production has the biggest share of water use by far and that wet processing hardly contributes. Maybe this is because the water is filtered before it comes out, and the amounts that go in and come out are almost the same, as the inventory analysis showed as well.

5.2.7 Abiotic depletion potential

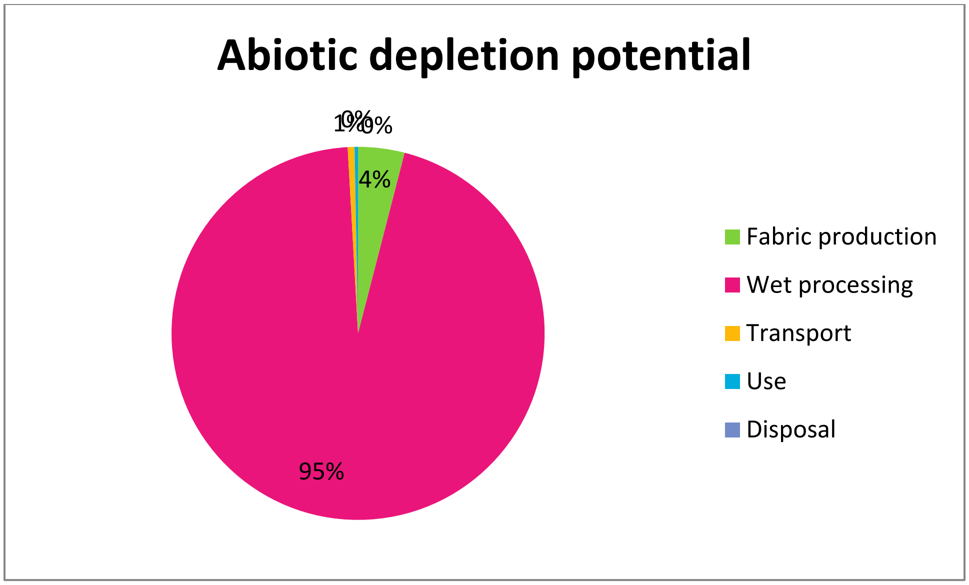


Figure 25. Characterization of Abiotic depletion potential for the jeans' life cycle

Abiotic depletion is for 95% based on the wet processing phases. It is not a surprise that these phases use a lot of resources, especially because the lining, buttons and other sundries are also included under wet processing and these are made from brass and plastic among other things. The research by Hackett (2015) shows a similar results, wit 78% of abiotic depletion being caused by sundries and packaging. 4% is made up by fabric production.

5.3 Summary and interpretation

Overall, the characterization results show very divergent results. There isn't one life phase that contributes most to all impact categories and the shares are divided very differently. In most case, one life phase contributes to the impact category a lot, while the others only make up a small share. An overview of all phases and impact categories can be seen in figure 26.

Fabric production contributes most to the global warming potential, eutrophication, acidification, ecotoxicity and water use. Fabric production consist of cotton cultivation, elastane production, cotton spinning and weaving and their electricity inputs. Cotton cultivation is particular is knows for using large volumes of fertilizers which can lead to eutrophication and pesticides, which are toxic to plants so they likely contribute to acidification and ecotoxicity. Another reason that is shows up with such large shares is that the information in that is used for this phase in this LCA is based on database information. Because of this, the inventory analysis includes many types of substances that apply to an average situation so they might be used in the production of this pair of jeans, but do not necessarily have to be.

Wet processing has the biggest impact when it comes to ozone depletion and resource depletion. Wet processing for this particular pair of jeans includes bleaching, dyeing, preparation and cutting, sewing, the production of the trims, finishing and laundry, as well as their electricity inputs. Because the complete production of the plastic buttons, metal buttons, lining, elastic and leather are included in this phase that might explain why this phase scores highest in resource depletion and ozone depletion is likely because of the volatile substances that are used for dyeing and finishing.

The use phase has the biggest impact on human toxicity. This might be due to the type of washing powder of liquid that was available in GaBi.

Transport has a very small impact in some of the impact categories, while the disposal phase is completely absent in the characterization. Both are most likely the result of missing information on these phases. Transport by boat over more than 12.000 km requires a lot of fuel, so it would make sense that this shows up in for example resource depletion but because the information could not be obtained from interviews the information is incomplete. For disposal it is even harder to trace what exactly happens because once a garment leaves the "gate", what happens with it is up to the consumer. Some clothes are donated to charity after use, some are reused as lower quality textile, some end up in house hold waste while other are collected as textile waste. Because the options are so broad and hardly influenced by the focal company, not having the exact results might not be much of a problem as they cannot really influence it anyway.

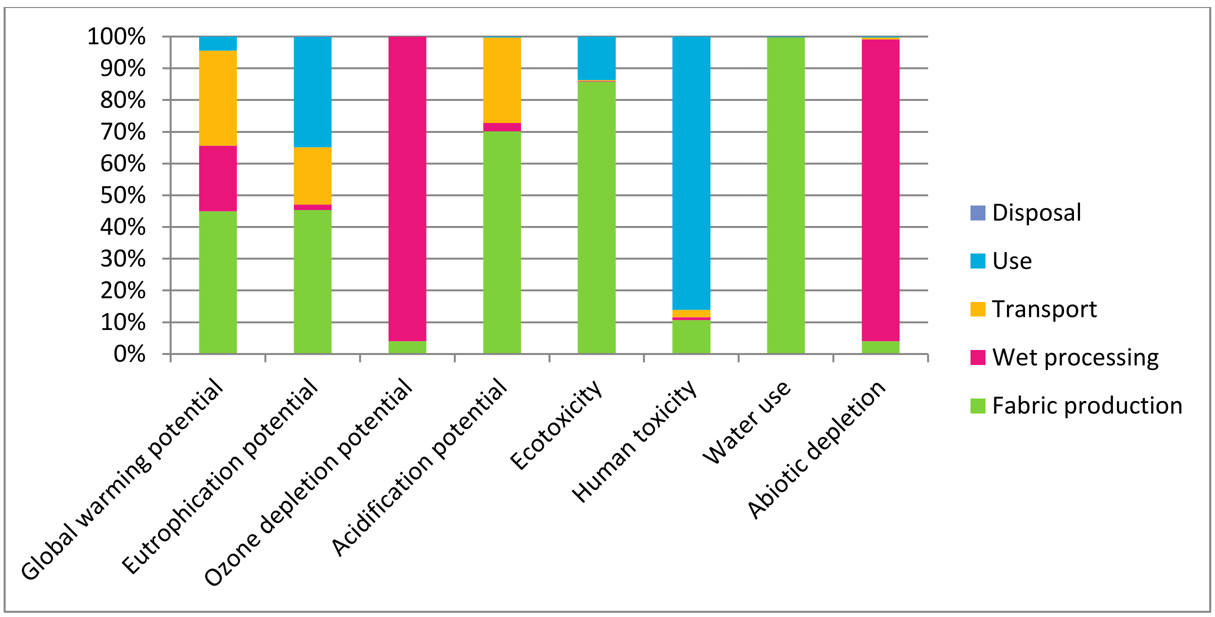


Figure 26. Overview of the characterization of different impact categories for the jeans' life cycle

6. Analysis and recommendations

In this research it showed that the fabric production contributes to a number of impact categories from water usage to eutrophication and acidification, as well as ecotoxicity. Wet processing also accounts for a couple of impact categories like resource use. It stands out that the use and disposal phases are hardly mentioned, which can be due to the fact that empirical evidence is only collected for the supply chain phases of the life cycle. This makes it interesting to look at different researches that emphasize different parts of the life cycle. Because of the subjective nature of LCA research, it is good to compare the results to other, similar researches to fill up any gaps and get a more complete overview of which impacts are most prominent. Below several different studies are discussed to see how this research fits into the existing life cycle knowledge on life cycle assessments in the clothing industry.

6.1 Comparable researches

Because LCA's performed by other clothing companies are often confidential, most researches this LCA can be compared with have an academic background. This is quite useful for comparison, as these researches are often heavily based on database information and therefore represent a general base line. Below, a few of these researches are discussed to see how this research compares to them. Two other methods for measuring life cycle impact are mentioned as well. Then a review of the results is given and recommendations are made based on the results and the comparison to other researches. This chapter will mainly focus on the results of the jeans, as the inventory analysis and the impact assessment of the t-shirt did not yield enough results to analyze.

One very extensive and comprehensible research is by EDIPTEX. Among other things, they researched a 100% cotton t-shirt from cradle to grave, but they looked at several scenarios for the same item, for instance by altering the washing temperature. They found that energy consumption was greatest for the use phase due to washing and tumble-drying. Energy related emissions and fossil fuel use where therefore also greatest in the life phase. This is not the case in this LCA because the t-shirt is only meant to be washed at 40°C and is not meant to be tumble-dried. Furthermore, the impact categories that are scored highest on are mainly human- and ecotoxicity, because of pesticide use in the cotton cultivation phase (Ellebæk Larsen et al., 2007). This research recommends that organic cotton is used rather than conventional cotton, but the main issue is not necessarily in the hands of a company: according to their research, the use phase contributes the most to almost all impact categories and other than adjusting the care label, this is not something that a company can change. A research by Defra is modelled with the same tool and shows the same results (Defra, 2009).

A research by BIOIS also shows that the use phase has the biggest impact by far when it comes to energy and water use. Again primarily because of tumble-drying and ironing, which makes the linen t-shirt that the cotton is compared with in this study environmentally even worse. Energy consumption and its consequences is again the biggest impact category, followed by fertilizer and pesticide use for cotton cultivation (BIOIS, 2007). That the use phase accounts for the biggest share of energy and water consumption is also explained in a joined study between BIOIS and ADEME, which focuses on a pair of jeans. They even made a tool based on their results, where as a consumer, you can compare different scenario's, like tumble-drying or not tumble-drying, to see how this affect several impact categories. Figure 27. shows a screenshot of the tool that includes the scenario of WE Fashion's boy's jeans.

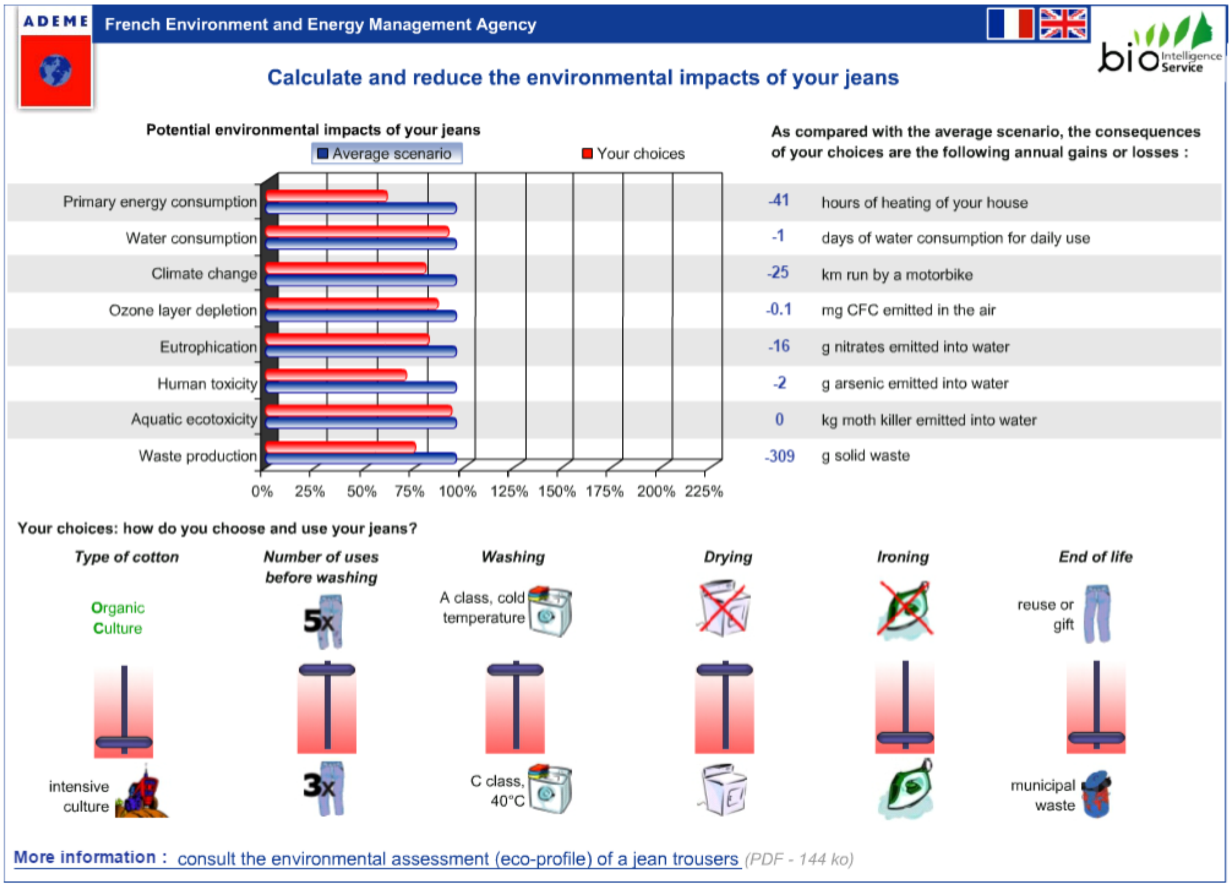


Figure 27. Online tool for comparing environmental impacts of jeans (ADEME-BIOIS, 2006)

Browne et al. also research jeans, but with a scope from cradle to gate and a main focus on transport. However, they found that transport doesn't have as much of an impact compared to manufacture and cultivation when it comes to energy use. The use phase is not included in this study, so as figure 28 shows, product manufacture has by far the largest impact (Browne et al., 2005).

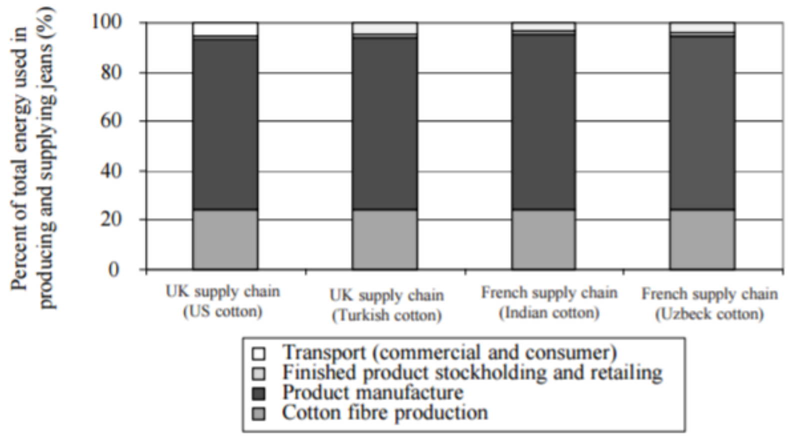


Figure 28. Energy use for the cradle to gate of a pair of jeans with different regional scopes (Browne et al., 2005)

A summary of the above studies is made by Chapman (2010) and figure 29 shows the visualization of the outcomes where blue is production, red is other phases, green is the use phase and purple is disposal.

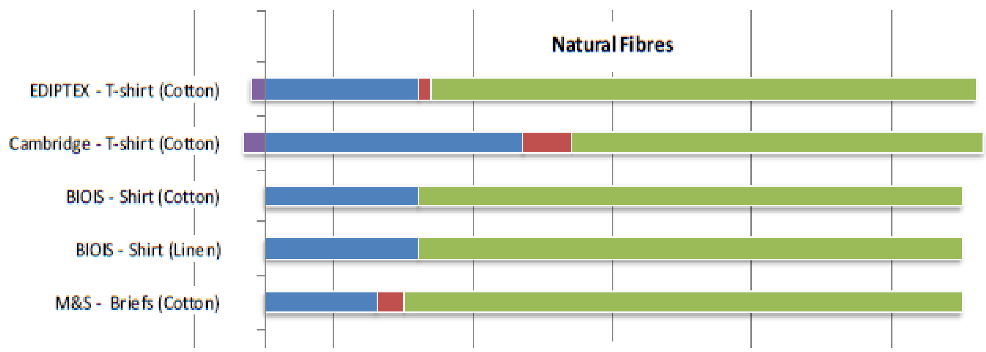


Figure 29. Outcomes of several LCA researches (Chapman, 2010)

It stands out that these results do not completely align with the result from this research. The main reason for this is the focus of the study. When the use phase is left out, like in the research by Browne et al., (2009), different life phases stand out as having a big impact. This research works with empirical data on the supply chain phases of the products, while the use phase is based on database results. This means that the focus is more on the supply chain as well. The results are not the same because tumble-drying generally has one of the largest impacts in a life cycle study on textiles, but because that is not (meant to be) done with these articles, the focus lies elsewhere. A research by Bijleveld and Bergsma (2015) compares the impact of different types of textile, under which linen and wool. Interesting about this research is that they also compare knitted and woven fabric. When it comes to cotton, they show that woven fabrics have a higher global warming potential and a higher impact in general.

In figure 30 and 31, the complete impact assessments of two other researches on jeans are visualized. Figure 32 is again the graph of the impact assessment of this research. While the chosen impact categories do not match completely, it is interesting to see how the three researched compare. It shows that in these researches too, fibre production makes up a big share of the impact, in different impact categories. The wet processing phases are hard to identify in the other two overviews, as they are part of “fabric and garment production” and include “cut, sew and finish” but it stands out that in the research by Roos et al. (2015) the fabric and garment production has the largest impact in almost all impact categories. In the overview by Hackett (2015), the most striking finding is the large share that transport and retail has on abiotic depletion, which can be linked to the large volumes of diesel.

That some of the results from this research do not match with other, comparable studies does not mean that the results are not reliable. As we’ve seen, parameters of the research aren’t the same and if they were, the regional or time scope can account for differences as well. LCA research remains uncertain and based on assumptions. It is undeniable that this research is lacking some results and might have some incorrect assumptions, but that might also be the case for the other studies. Therefore it is wise to use the different studies to fill in gaps and give a more complete and well-considered advise.

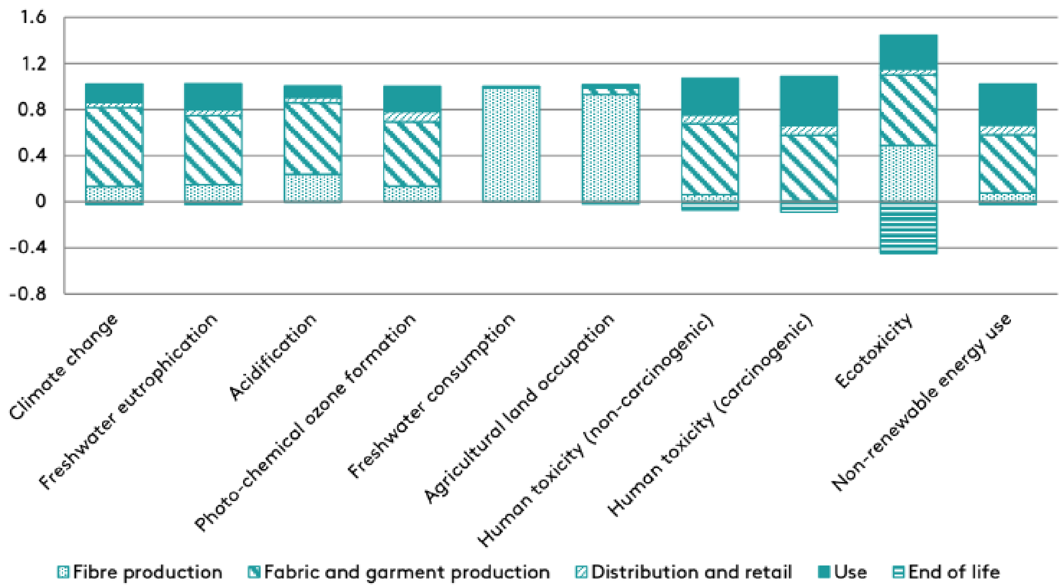


Figure 30. Overview impact assessment of a pair of jeans by Roos et al. (2015)

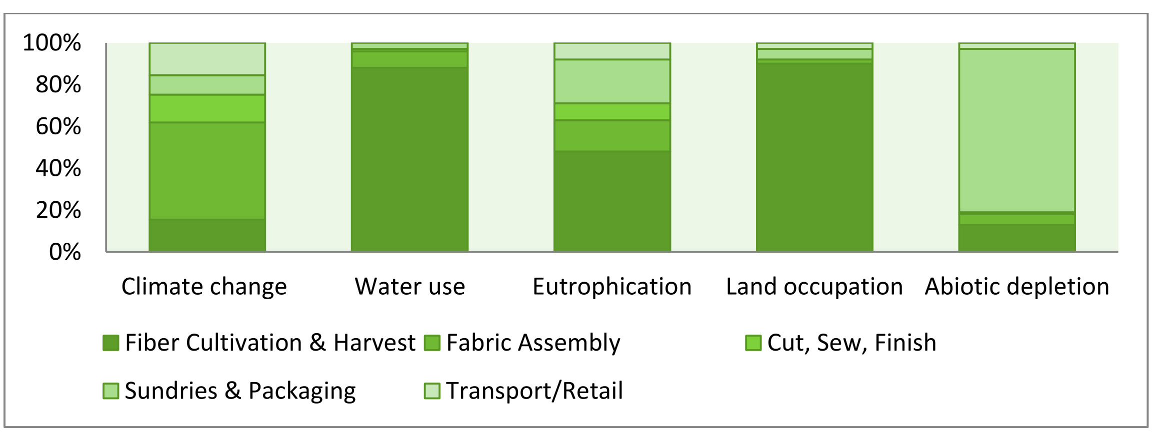


Figure 31. Overview impact assessment of a pair of jeans by Hackett (2015) visualization based on figure 4.1 to 4.13.

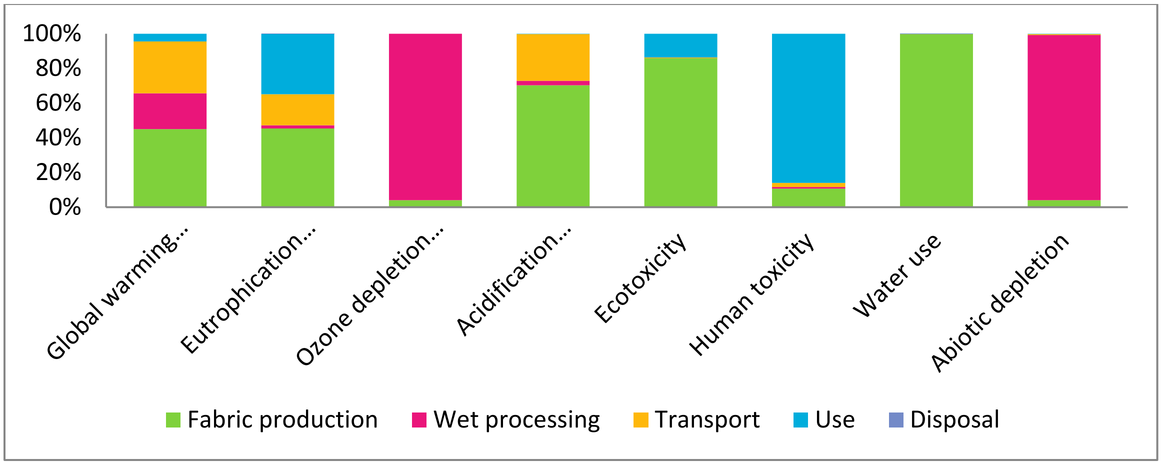


Figure 32. Overview impact assessment of a pair of jeans in this LCA

6.2 Review and recommendations

6.2.1 Limitations of this research

Life cycle assessment research is generally viewed as quite ambitious for companies. Firstly because it goes beyond their traditional responsibility and secondly because it requires a certain insight into the supply chain. This is easier for some companies than for others. Manufacturing or processing companies perform processes themselves, therefore they have first hand data to put into their inventory analysis and life cycle assessment. A retailer like WE Fashion is actually as far away from actual production as possible because they buy readymade garments. This also means that getting the right information to put in the LCA is hardest for them. In this research this has proven to be the case as well. The data that is received from the suppliers and sub-suppliers is limited in many ways. Reasons for this include the language barrier, too many links to the right producer, lack of knowledge or willingness/ability to share information due to confidentiality. Confidentially is one of the biggest limitations of a life cycle assessment that is both academic and in cooperation with a company. This is most evident from the fact that no information was the impact assessment on the t-shirt could not be performed due to lack of results, but it also influences other smaller decisions that need to be substituted by assumptions.

Because of this, the quality of the data is questionable. For the inventory analysis this means that the data is limited, but it does gives some insight into which chemicals suppliers use and if they are in line with European law. Furthermore, based on the inventory analysis a company could do a study on more environmentally friendly alternatives and advice their supplier with this information without linking it to certain impact categories. For the impact assessment it might be more problematic, as the results do not give a coherent overview of the issues. The first problem already occurred when an impact assessment of the individual processes did not yield any results. If a research like this would continue on for longer it might be possible to get more results, for instance by visiting the supplier or training the supplier on LCA research so that they understand better which information is needed.

Because of this, the quality of the data is questionable. For the inventory analysis this means that the data is limited, but it already gives some insight into which chemicals suppliers use. In another research, a study can be done on more environmentally friendly alternatives of these chemicals which would already be an improvement. If a research like this would continue on for longer it might be possible to get more results, in instance by visiting the supplier or training the supplier on LCA research so that they understand better which information is needed.

6.2.2 Usability of LCA research

The results from an LCA can be used in multiple ways by a company. In general, it can be used for product development, green marketing, production processes and waste management. Below these options will be discussed, followed by a more detailed recommendation for WE Fashion's CSR strategy.

6.3.2.1 Product development

Product development takes in one of the most central positions. Considering environmental impacts into the design of a product is also called eco-design or design for the environment (Baumann & Tillman, 2004). The results of an LCA can contribute to product development in multiple ways, in this case it has showed for example that the fertilizers used in cotton cultivation have a big impact of eutrophication. With this knowledge, a company can design a certain piece of clothing to be made out of better cotton or organic cotton, which generally uses less fertilizers.

Not just the composition but other characterizations of the design can change the environmental impact as well. In general there are 7 different practices: choice of materials, choice of components, product features, use of energy, distribution of products, packaging and documentation and waste (Borchardt et al., 2011). Substituting the conventional cotton for organic cotton is an example of the choice of materials, the choice of components would for example mean choosing not to use any elastane, redesigning the pattern so less fabric would be lost and so on. Many options are possible in this regard but before they can be implemented, it needs to be researched what the characteristics other than environmental impact would be.

6.2.2.2 Green marketing

Green marketing concerns the use of eco-labels and other ways to market the sustainable properties of a product. There are three types of labels according to the OECD, Type I and III labels are independent and internationally recognized eco-labels like the Marine Stewardship Councel (MSC) and they are designed to help consumers make the more sustainable choice within a product group. But type II labels are connected to individual companies and therefore often contain one-sided information (Galarraga Gallastegui, 2002). Making the difference between the three is not always easy, which makes eco-labelling tricky. Because it is used to sell the product, companies can "green wash" the product and make it look more sustainable than it is. On the other hand, green marketing is a very useful tool for both business partners and consumers that are looking for more sustainable purchases to make more aware choices (Baumann & Tillman, 2004).

WE Fashion already has separate labels for their products that are made out of environmentally friendly materials like organic cotton and linen, which intent to help the costumer to make a more informed choice. This works well as these are type I based labels with an independent nature, but while LCA results can be used to shows transparency, dedication and progression, it is not wise for WE Fashion to directly use them in marketing strategies. This is mainly to the subjective nature of LCA and the great variety in methodology, despite the ISO 14040 being a set standard (Baumann & Tillman, 2004). It is not easy to simply convey the exact details on how LCA results are established and therefore they should not be used to appraise a certain quality of a product.

6.2.2.3 Production processes and waste management

LCA research for product processes and waste management focuses on the up-stream processes (before the use phase) in the life cycle of a product (Baumann & Tillman, 2004). In the textile industry there are many processes that can be performed in multiple ways. Dyeing for instance can be done in batches or continually and waste streams can be disposed of, or they can be recycled. To find out which option is best in terms of environmental impact you should again do a comparative LCA research and you would have to have quite a lot of influence into the manufacturing stages. A retailer like WE Fashion does not determine in which way a product is dyed, they want a certain end results and how it is achieved is not discussed other than that it has to meet certain standards and laws.

6.2.3 Recommendations for WE Fashion

6.2.3.1 Usability of LCA research for retailers

Life cycle assessment is a tool that can be very useful for a company because it is so detailed and it gives insight into the whole supply chain, but these features are also the reason that it is very hard to implement for a retailer like WE Fashion. As can be seen in the inventory analysis and the impact assessment, it is very hard to get the right results from suppliers and the less information is filled in, the less valuable the results of an LCA are. This all comes down to the fact that retailers like WE Fashion do not have complete control over their supply chain because they buy ready-made garments. Because they aren't part of the production process, they cannot require producers to use a certain dye or overall process, because they can only put in demands for the end product. Adopting a more brand like style of involvement would ask for a lot more money and time and even then it might not be possible because of the sheer size of the company and the collections.

For a retailer, other methods for monitoring environmental impact might be more suitable. The social compliance method that WE Fashion is very widely recognized, closely monitored and easily workable within WE Fashion, a similar system for environmental sustainability would fit them well. In contrast to LCA, environmental auditing would be performed on sight by an independent entity. This deals with both the language barrier and the knowledge barrier, as the auditor should have the appropriate knowledge to recognize the relevant impacts. Furthermore, confidentiality could be death with through translating the results to a ordinal scale. Environmental auditing is not only a good fit, it is also a realistic option because the FTA, which also commissions the BSCI, is developing an environmental auditing system called Business Environmental Performance Initiative (BEPI).

6.2.3.2 Using the results within CSR strategy

Even though the LCA results are not suitable to be translated into direct recommendations, some lessons can still be learned from it. What stands out most in the results of the LCA on the boy's jeans is that the fibre production phase requires a lot of resources, has a lot of outputs and therefore is linked to several impact categories. Even though the information used is based on general information from China rather than the actual cotton farmer, the data is likely to be quite representative. It might be valuable for WE Fashion to look into the possibility to substitute the conventional cotton that makes up 99% of the main material for a more sustainable option like better cotton or organic cotton. We know that organic cotton for instance uses less fertilizers and pesticides, so you would expect the eutrophication and acidification to decrease. But both of these options have different qualities and a different impact on social sustainability, so to be sure if this would make a significant difference it might be useful to do an LCA or other study comparing three cotton products, one with conventional cotton, one with better cotton and one with organic cotton.

Wet processing also accounts for a couple of impact categories like resource use, but it is also generally known for producing a lot of waste water. Here, the focus might be more on the processes themselves. If a way can be found to do laundry with smaller amounts of water for example, this might limit the water intake of the phase. Alternative processing like enzymatic processing, biodegradable components and dry dyeing are options that can be explored for this (Varadarajan & Venkatachalam, 2016). However, because WE Fashion buys readymade garments they do not make this decision. Moreover, they buy most of their products from suppliers that produce for several other brands and retailers in the same factory. This means that altering a process, might alter the process for products of other companies as well. This is not a disadvantage per se, as a cooperation with this other companies might make for a stronger position in a dialogue about changing certain processes.

According to the results of the research, the use and disposal phase of the life cycle of this product do not account for much of the impact. If they did, WE Fashion could only indirectly try to change this. For the use phase, they can instruct customers on how to handle the product through the care label. For instance the instruction not to tumble-dry the jeans saves a lot of energy according to other LCA studies. In terms of disposal WE Fashion could invest in a more prominent recycling system, where clothes can be brought back to the store to be used in production again. To see how valuable this would be, another research is required.

7. Exploring social sustainability in the supply chain

7.1 Social impact tools

Life cycle assessment leads to insight into the environmental impact of a piece of clothing, but cannot say anything about the social aspect of sustainability which is also part of the product system. This is mainly because of the nature of the part it plays in the system. Environmental impacts are embedded in the processes that take place during production. Water pollution is inseparable from dyeing and can also be retraced when a piece of clothing is tested for chemicals. There is a link between processes and environmental impacts that is causal and direct (Jorgensen et al., 2008). Social impacts do not correlate with the processes through which a piece of garment goes, they are related to the context in which the process takes place. This means that social impact says something about the company, rather than the product (Dreyer et al. 2006). Therefore the focus lies on the companies that perform the processes when assessing social standards.

Because of the complicated nature of social sustainability there are several ways this concept can be explored. Several tools are known in academic literature that can help assess social impact within a company. A number of these will be discussed below to see which is most suitable for a small, explorative application on the two products that are also assessed through the LCA.

7.1.1. Social life cycle assessment

Social life cycle assessment is a concept created in the attempt to add socio-economic concerns to life cycle assessment. Like LCA, it is a tool that collects data in the whole life cycle of a product and tries to translate this data to impacts (Benoît et al., 2010). While studies have found that the integration of social impact into LCA can be feasible (Grieβhammer et al., 2006), there are many obstacles, some more relevant in an academic context while others apply more to the commercial side.

Because social sustainability says more about the production site rather than the process, it is questionable how usable SLCA is for assessing social impacts in an academic context, because it only displays the social circumstances in one location so the information is even less generalizable than environmental life cycle assessment. Rather than assessing the impacts of a life cycle of a particular product, it might be better to assess social impacts based on larger samples and more general issues. Like through risk assessment based on the performance of a country. In a commercial context, the fact that social sustainability mainly focusses on the production site, rather than the product makes it very precarious. Supplier and factories that indulge in practices like child labour are likely not willing to share the exact data on what they do, because that is bad for their reputation and in most cases also illegal. Nonetheless, in other tools like auditing this information is shared, so we will get back to that.

The nature of social data poses one of the biggest issues for this kind of tool. While environmental issues are based on scientific knowledge of the influence of substances on the natural world, social standards are a construct that is created by humans themselves. Simply said, this means that what is a social problem in one country might not be perceived as a problem in another country (Grieβhammer et al., 2006).

7.1.2. Risk assessment

Another tool that is used for both environmental and social issues is risk management. The risk in this case often does not just entail the change of losing economic profit, but not achieving your targets in general which makes it also useful from a sustainability perspective (Freise & Seuring, 2015). A responsible company includes CSR in its risks and even has specific sustainability goals. Risks apply to the factory, but because the supply chain contributes to the reaching of targets, it is very important to include the supply chain and focus on supply chain risk. Pfohl et al. (2010, p. ?) describe this as follows: ''Supply chain risks involve risks that can be attributed to disturbance of flow within the goods, information, and financial network, as well as the social and institutional networks. They might have negative effects on the goal achievement of single companies and the whole supply chain, respectively, with regard to end customer value, costs, time, or quality''.

We Fashion actually has already done a risk assessment for internal use only, which is based on the social indicators that are used in the BSCI auditing system. Based on how often an issue is scored insufficiently in audits, the likelihood of the risk is ranked. Then, the impact of the risk is determined along a table with different effects on the company as well as the worker's life. This yields a score that indicates how high the risk of a certain social issue is in WE Fashion's supply chain. Because of confidentiality, the results cannot be revealed. Again, this shows that one of the biggest limits of this kind of research is confidentiality within companies.

7.1.3 Auditing

As mentioned before, WE Fashion is actually already monitoring social sustainability of their first and second tier suppliers through auditing. An audit is an official inspection of a company, often by an independent body. In this case, this body is the Business Social Compliance Initiative (BSCI), which is an initiative by the Foreign Trade Association (FTA). They have one code of conduct on which all audits are based. All producers WE Fashion works with should be in a valid audit cycle. This cycle is set up as follows: as the focal company, WE Fashion authorizes an audit, which the producer pays for themselves. When the audit is completed and scored an A or a B, the audit is valid for two years and no other action is needed. When an audit is scored a C, D or E another audit must follow within a year after the first one. The producer is expected to upload a remediation plan and to have improved once the new audit comes along.

The audit itself consists of a lot of questions and inspections. Some are open like the minimum wage as well as the living wage for that area compared to the actual wage, as well as the legal working hours and over hours, compared to the actual working hours. The main part of the audit is the scoring of several social indicators. These indicators all consist of a number of questions, some more crucial than other. For instance, fire safety issues and getting enough resting breaks are very important indicators that are judged very strictly. The different impact categories, or "Performance Area's" as BSCI calls them are:

- Social Management Systems and Cascade Effect
- Workers involvement and Protection
- The rights of Freedom of Association and Collective Bargaining
- No Discrimination

- Fair Remuneration
- Decent Working Hours
- Occupational Health and Safety
- No Child Labour
- Special protection for young workers
- No Precarious Employment
- No Bonded Labour
- Protection of the Environment
- Ethical Business Behaviour

All categories get a score from A to E, A means outstanding, B stands for good, C for acceptable, D for insufficient and E for unacceptable. For some issues, there is a zero tolerance policy, which means that is these violations are found the audit is stopped and action has to be taken by all companies that produce in the factory. Examples of zero policy issues are proof of child labour of bonded labour. All categories together yield a total score for the audit, which is also A to E and determines the duration of the validity as mentioned above.

Another standard for auditing is that of the Fair Wear Foundation. The Fair Wear Foundation is a non-governmental organization that works on improving social standards in the clothing industry through several different media, of which auditing is one. Even though their auditing system is much less widely used than BSCI, its requirement are more strict and because it is an organization that is in constant dialogue with other parties, they include the viewpoints of local stakeholders. Which makes for a good comparison of the audited factory to the general score.

Having an auditing system means that WE Fashion actually has insight into the social sustainability connected to the two products but there are a few downsides. Firstly, right now auditing mainly covers garment producing factories. Because these factories are the last link in the supply chain and they are often owned or work for a supplier, they can be monitored quite easily, while their subcontractors and sub-suppliers are much harder to track down. The performance area "Social management systems and cascade effect" by BSCI rates this, but only requires a producer's partners to be aware of the BSCI Code of Conduct, not to implement it as well. Secondly, sensitivity of the data applies here most of all, if WE Fashion was to publish the audits they have on certain products, this information says something about the factory but not so much about the garment. Because this information is specific to a factory, they might not appreciate it if their business partner publishes information about them.

7.2 Social situations in practice

When comparing the tools above, a few things stand out. Firstly, it is wise to take a general sample, rather than one factory to say something about social sustainability because of the nature of the data. Secondly, standardizing the results is hard, therefore we shouldn't try to standardize and focus on describing and comparing the qualitative data instead because there is a lot to say about this and it is still possible to score it, like is happening in audits. Because of this, to assess the social impact of the two selected pieces of clothing a combination of these three is used. In order to include the supply chain, a distinction is made between the fibre phase, the yarn phase, the fabric phase and the garment phase of the supply chain. For each phase the country where it is performed is specified. About the country, a descriptive analysis is given based on another stricter, but less used auditing system: the auditing system of the Fair Wear Foundation. The Fair Wear Foundation is an NGO that helps companies to improve environmental and social circumstances in the clothing industry. What sets their auditing system apart is that for every social indicator, it contains a part that is based on interviews with local stakeholders. This gives an overview of the most prominent issues in this area, based on a country study they did on several risk countries although it does not apply exactly to WE Fashion's situation, it gives insight into the problems in certain countries. This is followed by some risk assessments that others have performed in these countries. , as well as some risk assessment results. For convenience, only the main material is considered, as it makes up at least 80% in all of the products.

As is displayed in the results, the men's t-shirt is completely produced in Turkey and the fibre and yarn production phases for the boys jeans are produced in China, while the fabric and garment phases are performed in Bangladesh. In all these countries, the most issues occur regarding the following social indicators, which is why they will be discussed for each country: Freedom of association and the right to collective bargaining, payment of a living wage, reasonable hours of work and safe and healthy working conditions.

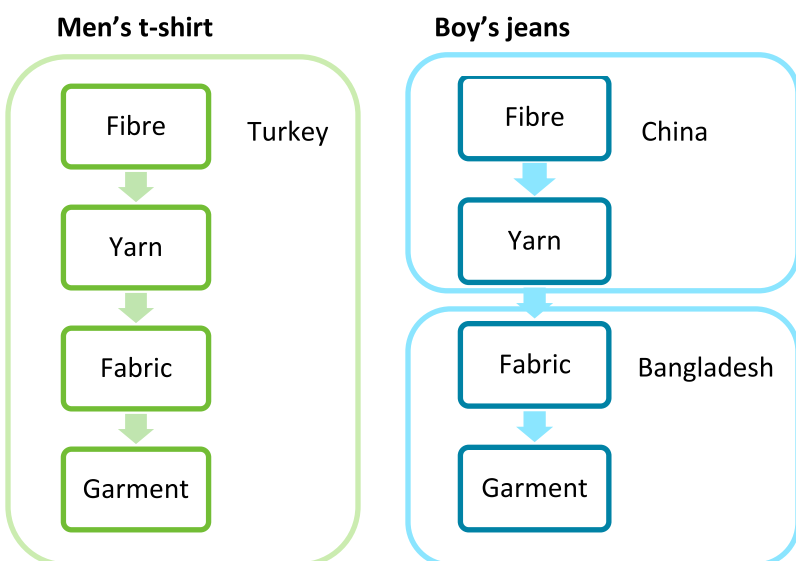


Figure 33. Regional scopes of the production of main material for the selected pieces of clothing.

7.2.1 Men's t-shirt from Turkey

Turkey seems a relatively wealthy and developed country. It is currently applying for EU membership and being in 72nd place on the 2015 Human Development Index they are in the high development category. But in terms of textile production circumstances Turkey is considered a risk country. As reflected in the current political situation, human rights aren't always protected in Turkey, which is why Turkish factories and suppliers need to be audited when exporting to the Dutch market. One issue that stands out in Turkey is the illegal employment of Syrian Refugees. Since 2011 a lot of Syrian refugees have fled to Turkey. To support their families they are desperate for work, which makes them an easy target for precarious working conditions, low wages and illegal contract (Fair Wear Foundation, 2016).

Freedom of association and the right to collective bargaining

When it comes to collective bargaining, Turkish law does not comply with the rules of the International Labour Organisation (ILO) and in practice legislation is often evaded. As a worker, proving your right in disputes is very costly and a lawyer is too expensive for most workers. Stakeholders affirm this and it also reflects in audit results, where 14% have issues in this area and 30% of audited factories have no independent union (Fair Wear Foundation, 2016).

Payment of a living wage

Turkey has a minimum wage installed, but is seems that this is not sufficient as a living wage for a large part of society as for example 35,8% of the population cannot afford to eat meat or fish every day. Stakeholders also affirm that the minimum wage is not sufficient to live from, while 100% of all audits by FWF show that the wage paid is below the living wage. Furthermore, 17% even paid less than minimum wage (Fair Wear Foundation, 2016).

Reasonable hours of work

The maximum amount of working hours per week in Turkey is 45, with days of 11 hours maximum. Over hours can be up to 270 hours per year. But because Turkey is relatively close to Europe, compared to the other textile processing countries it is often used for short lead times. This causes over hours to pile up and combined with the low wages, workers are inclined to work these over hours anyway. 60% of all FWF audits in the last two years who excessive overtime and often, workers do not receive a premium for these extra hours (Fair Wear Foundation, 2016).

Safe and healthy working conditions

Laws and regulation regarding safety and health in Turkey are often not followed closely. This has lead to 12.041 work accidents in the garment industry in 2015 alone. Local stakeholders declare that the situation has become better in factories that export, because of regular auditing. One point of critique is that the factories often employ their own health experts to which workers have to turn when they have issues, but as these experts aren’t independent it is unclear how effective this is. Almost all audits from the last two years show that improvement is needed in this area (Fair Wear Foundation, 2016).

7.2.2. Boy’s jeans from China and Bangladesh

China is the biggest garment processing country in the world. It has one of the biggest populations and ranks 90th on the Human Development Index, but on the Democracy Index they are at 136, which is quite low. It is a risk country for several reasons. The most apparent issue in China relates to the working hours. Unlike in other Asian countries where the standard is 48, the maximum weekly hours in China is 40. Because they are required to deliver as fast and as quick as their neighbor countries, this results in extreme over hours (Fair Wear Foundation, 2016).

Bangladesh is a small Asian country that ranks 142 on the Human Development Index. Although they are ranked as a lower-middle income countries, they have one of the lowest minimum wages worldwide and 76,5% of the populations lives of less than $2 a day. The human rights situation is also fickle, some rights are protected by law but they aren't always sufficient and they aren't always followed (Fair Wear Foundation, 2015).

Freedom of association and the right to collective bargaining
Worker unions are uncommon in China, this is grounded in Chinese law which describes that all unions have to be linked to the national union controlled by the government, the All China Federation of Trade Unions (ACFTU). This dependence creates conflicts of interest and several NGO's are therefore pressing for more democratic, independent unions that are also accessible for lesser informed migrant workers who often accept the circumstances out of lack of choice (Fair Wear Foundation, 2010).

In Bangladesh, worker unions are allowed by law but forming them is difficult because of other factors. Firstly, a lot of people in Bangladesh do not work in the formal sector and while the clothing industry is formal, they are often not aware of their right to freedom of association. Moreover, issues have occurred in the past, where union leaders have been fired from the factory where they work, this also discourages people from joining a union. However, the situation is improving and factory owners start to recognize that unions aren't necessarily bad for business (Fair Wear Foundation, 2015).

Payment of a living wage
Minimum wage in China does not match living wage in many regions. However, the number of factories that pays the living wage is increasing. One issue that makes this standard hard to measure is the difference between pay by time or pay by piece rate. When workers are paid by piece rate, they receive money according to how many products they finish, which means that in peak seasons they earn a lot more. The downside is that in low seasons, they sometimes earn not enough to provide for their families (Fair Wear Foundation, 2010).

Bangladesh is known to be one of the poorest countries in the world. 31,5% of people live below the national poverty line even though the Bangladeshi law states the following: 'It shall be a fundamental responsibility of the State … securing to its citizens (a) the provision of the basic necessities of life, including food, clothing, shelter, education and medical care; (b) the right to work, that is, the right to guaranteed employment at a reasonable wage …' (Fair Wear Foundation, 2015, p. 28). Minimum wages are determined per industry by the Wage Board. The last time it was raised, the minimum wage went up with 77% (Fair Wear Foundation, 2015), but inflation has all swallowed it since (Smith, 2013). Furthermore it was lead to more overtime because costs are implemented at factory owner level and workers in higher salary scales have been downgraded to keep costs low (Fair Wear Foundation, 2015).

Reasonable hours of work
As said, China has regular working hours of 40 hours per week and 8 hours per day. Many surrounding countries in the same industry have regular working hours between 45 and 48 hours a week, while receiving the same amount of orders. Because of this, excessive overtime is the biggest issue in the Chinese garment industry. Workers still accept these circumstances because they can use the extra money so that they might earn a living wage and because foreign clients often expect orders in the same amount of time as they would from other countries (Fair Wear Foundation, 2010).

Normal working hours in Bangladesh are set at 48 hours per week, with 8 hours of work per day. Legally, over hours can be two hours per day and 60 hours per week, but a premium needs to be paid. Because normal wages aren't enough to live from, many workers want to work overtime to get a more decent income. But they do not always receive the promised overtime premium, even though they often work a lot more than 60 hours per week (Fair Wear Foundation, 2015).

Safe and healthy working conditions

Safety and health regulations are relatively well cared for in China, every factory has to establish a health and safety committee and fire safety is especially monitored carefully so not many issues are found in this area. Nonetheless, the accident rate is high due to excessive working hours. Ergonomic issues are also tied to this, as workers are required to perform certain tasks for long periods at a time, but these problems are less obvious (Fair Wear Foundation, 2010).

In 2013 the Rana Plaza building in Dhaka collapsed due to unsafety of the building, costing more than 1100 people their lives and several hundred others were injured. This disaster, as well as many others preceding it has lead to serious reform in the building and safety regulations in Bangladesh and the clothing industry in general, under which the Triparte Statement which is also signed by the government and the Accord on Fire and Building Safety in Bangladesh of which WE Fashion is also a part (Fair Wear Foundation, 2015).

Another consequence of this is that in the BSCI auditing system for instance, fire safety requirements are critical, which means that scoring an insufficient in these categories will yield a significantly lower score in these types of audits (BSCI). Stakeholders see that this has really improved working conditions for Bangladeshi workers, but there is still a long way to go. Even though building- and fire safety are closely monitored now, protective equipment, light and air circulation and hygiene still need improvement in many factories (Fair Wear Foundation, 2015) and a risk assessment done by BSCI shows that health and safety issues still frequent in Bangladesh as well as other countries.

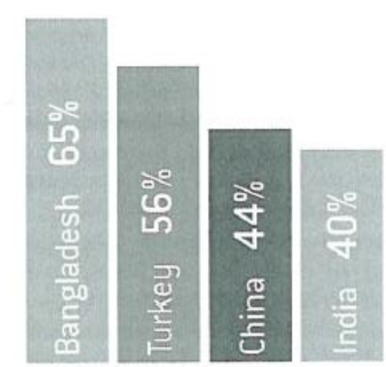


Figure 34. Percentage of factories in the four main sourcing market with high health and safety risks (FTA, 2016)

7.3 Recommendations regarding social sustainability

Because of the general nature of the social sustainability in this research not much can be recommended to WE Fashion. They already have a consistent social auditing system in place and they are involved in other projects to improve social standards as well. Nonetheless, some hot spots that can be identified from the FWF country studies. In Turkey freedom of association and the right to collective bargaining, payment of a living wage, reasonable hours of work and safe and healthy working conditions are all points of interest. Partly because they are rooted in national laws but also because of short lead times, which is why it should be monitored continually. In China, decent working hours are the biggest problem, as their standard working week is shorter than that of surrounding companies and in Bangladesh the well known low wages and health and safety issues are something to keep in mind.

8. Conclusion

The fashion industry is a multinational business with a growing impact on both the environment and societies worldwide. Many clothing companies, under which WE Fashion, are working to improve their share of the issues that come with growing consumption, but with production mainly taking place on the other side of the world this is easier said than done. It starts with getting more insight into your supply chain and the environmental and social issues that accompany it. We Fashion want to learn more about their environmental impact through a Life Cycle Assessment from cradle to grave of two of their products, to see how the results can be used. The goal of the research has been to find out where in the life cycle of a t-shirt and jeans the biggest environmental impacts can be identified, in order to help in anticipating the best next step in WE Fashion's CSR strategy and looking at the usability of LCA for other products in the future. To reach this goal, a men's t-shirt and a boy's jeans where selected for the LCA research. Through surveys, supplemented with database information LCA software GaBi has led to some interesting results on the boy's jeans, while not enough results were collected on the men's t-shirt.

The inventory analysis of the jeans shows that chemical in and output are largest in the cotton cultivation phase. The water usage, as well as waste water output, is biggest for the laundry process but energy use is bigger for the bleaching process. it seems like the laundry phase had the most impact of all wet processes, but because of the limited received data, it is likely that some additional inputs and outputs can be added to this finding. Use and disposal are modelled after average figures but do not require or contribute much, unlike in many other LCA researches. The difference is that these products should not be tumble-dried, a process that normally needs a lot of electricity.

What stands out most in the results of the LCA on the boy's jeans is that the fibre production phase requires a lot of resources, has a lot of outputs and therefore is linked to several impact categories. It might be valuable for WE Fashion to look into the possibility to substitute the conventional cotton for a more sustainable option like organic cotton. Wet processing also accounts for a couple of impact categories like water and resource use. Here, the focus might be more on the processes themselves. If a way can be found to do laundry with smaller amounts of water of different kinds of dye for example, this might limit the impact of the phase. Social sustainability is not so easily captured in a quantitative tool, the nature of the data is both too diverse and too sensitive to measure case specific for this research. WE Fashion already has a consistent auditing system in place, but should watch out for certain hotspots. In Turkey, multiple pressing issues deserve attention while in China excessive overtime poses the biggest problem and in Bangladesh the wages should be carefully watched.

Life cycle assessment has an interesting place within corporate sustainability. Seeing how hard it was to collect information for the inventory analyses and impact assessments in this research it makes sense that there are hardly any publically available LCA's done within companies. Language barriers, knowledge gaps and confidentiality make LCA a very limited tool for an academic and commercial environmental impact research. Some general lessons can be learned from it, like that cotton fibre production has a large environmental impact on many fronts and that wet processing does some harm, but to know these facts, this research did not have to be performed. It has however shown the strengths and weaknesses of LCA research and that a more detailed, less general tool might be more suitable.

9. References

ADEME, BIOIS (2006), An Environmental Product Declaration of Jeans, ADEME/BIOIS [Report]. Location of tool: http://www3.ademe.fr/internet/eco-jean/

Agyeman, J. (2012). Fair shares of Oxfam's doughnut?

Amaeshi, K. M., Osuji, O. K., & Nnodim, P. (2008). Corporate social responsibility in supply chains of global brands: A boundaryless responsibility? Clarifications, exceptions and implications. *Journal of Business ethics*, *81*(1), 223-234.

Baumann, H., & Tillman, A. M. (2004). *The Hitch Hiker's Guide to LCA. An orientation in life cycle assessment methodology and application*.

BCI. (2013). Better Cotton Initiative. [Website]. From: http://www.bettercotton.org, accessed last on: 23-02-2017

Benoît, C., Norris, G. A., Valdivia, S., Ciroth, A., Moberg, A., Bos, U., ... & Beck, T. (2010). The guidelines for social life cycle assessment of products: just in time!. *The international journal of life cycle assessment*, *15*(2), 156-163.

Bijleveld, M. M., & Bergsma, G.C. (2015). Milieu informatie textiel. Milieu Centraal. CE Delft, Delft

BIOIS (2007), LCA to compare a linen/flax shirt with a cotton shirt

Borchardt, M., Wendt, M. H., Pereira, G. M., & Sellitto, M. A. (2011). Redesign of a component based on ecodesign practices: environmental impact and cost reduction achievements. *Journal of Cleaner Production*, *19*(1), 49-57.

Boström, M., & Micheletti, M. (2016). Introducing the Sustainability Challenge of Textiles and Clothing. *Journal of Consumer Policy*, *39*(4), 367-375.

Browne, M., Rizet, C., Anderson, S., Allen, J., & Keita, B. (2005). Life cycle assessment in the supply chain: a review and case study. *Transport Reviews*, *25*(6), 761-782.

Brundtland Commission. (1987). Our common future: Report of the World Commission on Environment and Development. *UN Documents Gatheringa Body of Global Agreements*.

Carson, R. (1962). *Silent spring*.

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. International journal of physical distribution & logistics management, 38(5), 360-387.

Chapman, A. (2010). Mistra future fashion–review of life cycle assessments of clothing. *Oakdene Hollins Research & Consulting, Stockholm*.

Defra (2009), Well Dressed? [Report].

Dreyer, L. (2006). Interpretation of the Fundamental ILO Conventions into Business Context–Background for development of indicators for Social LCA. *Department of Manufacturing Engineering and Management, Technical University of Denmark, Lyngby, Denmark*.

Dyllick, T., & Hockerts, K. (2002). Beyond the business case for corporate sustainability. *Business strategy and the environment*, *11*(2), 130-141.

Eberle, H., Hermeling, H., Hornberger, M., Menzer, D., Moll, A., Ring, W. (2008). *Clothing technology: …from fibre to fashion*. Fifth edition. Nournet, Vollmer BmbH & CO. Haan-Gruiten

Ellebæk Larsen, S., Hansen, J., Knudsen, H. H., Wenzel, H., Larsen, H. F., & Møller Kristensen, F. (2007). *EDIPTEX–Environmental assessment of textiles*. Danish Ministry of the Environment, Environmental Protection Agency.

European Commission, Corporate social responsibility (CSR). (2011). A Renewed Strategy 2011-14 for corporate social responsibility. Brussels. European Commission. Europa

Fair Wear Foundation. (2010). An Anonymous Audit Report from China. [Report]. Received from: https://www.fairwear.org/news/an-anonymous-audit-report-from-china/

Fair Wear Foundation. (2015). Bangladesh Country Study 2015. [Report]. Received from: https://www.fairwear.org/resource/bangladesh-country-study-2016-2/

Fair Wear Foundation. (2016). Turkey Country Study 2016. [Report]. Received from: https://www.fairwear.org/resource/turkey-country-study-2016/

Faruk, A. C., Lamming, R. C., Cousins, P. D., & Bowen, F. E. (2001). Analyzing, mapping, and managing environmental impacts along supply chains. *Journal of Industrial Ecology*, *5*(2), 13-36.

Finnveden, G., Hauschild, M. Z., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., ... & Suh, S. (2009). Recent developments in life cycle assessment. *Journal of environmental management*, *91*(1), 1-21.

Finnveden, G., & Moberg, Å. (2005). Environmental systems analysis tools–an overview. *Journal of cleaner production*, *13*(12), 1165-1173.

Fletcher, K. (2014). *Sustainable Fashion and Textiles: Design Journeys.* Routledge

Foreign Trade Association (FTA). (2016). Textile Sector FTA Industry Risk Assessment. [Private Report]. Privately obtained through the Foreign Trade Association.

Freise, M., & Seuring, S. (2015). Social and environmental risk management in supply chains: a survey in the clothing industry. *Logistics Research*, *8*(1), 1-12.

GaBi. (2017). GaBi Paper Clip Tutorial. Part 1. Intorduction to LCA and modelling in GaBi. [Instruction Manual]. ThinkStep. Retrieved from: http://www.gabi-software.com/fileadmin/GaBi_Manual/GaBi_Paperclip_tutorial_Part1.pdf

Gladwin, T. N., Kennelly, J. J., & Krause, T. S. (1995). Shifting paradigms for sustainable development: Implications for management theory and research. *Academy of management Review*, *20*(4), 874-907.

GOTS. (2011). Global Organic Textile Standard (GOTS).

Grießhammer, R., Benoît, C., Dreyer, L. C., Flysjö, A., Manhart, A., Mazijn, B., ... & Weidema, B. (2006). Feasibility study: integration of social aspects into LCA.

Hagelaar, J. L. F., van der Vorst, J. G. A. J., & Marcelis, W. J. (2005). Organising Life-cycles in Supply Chains: Linking Environmental Performance to Managerial Designs. *Greener Management International*, *2005*(45), 27-42.

Hawley, J. M. (2009). Economic impact of textile recycling. *Sustainable Fashion: What's Next? A Conversation about Issues, Practices and Possibilities*, 9.

Hays, P. A. (2004). Case study research. *Foundations for research: Methods of inquiry in education and the social sciences*, 217-234.

Herrmann, I. T., & Moltesen, A. (2015). Does it matter which Life Cycle Assessment (LCA) tool you choose?–a comparative assessment of SimaPro and GaBi. *Journal of Cleaner Production*, *86*, 163-169.

Hunkeler, D., & Rebitzer, G. (2003). Life Cycle costing—paving the road to sustainable development?. *The international journal of life cycle assessment*, *8*(2), 109-110.

ISO 14040. (2006). Environmental management -- Life cycle assessment -- Principles and framework. [Report]. From: http://www.iso.org/iso/catalogue_detail?csnumber=37456. Last used on 09-02-2017

Jonker, J., Stegeman, H. and Faber, N. (2017). Circular Economy: Developments, concepts, and research in search for corresponding business models, White Paper Nijmegen School of Management, Nijmegen: Radboud University

Jørgensen, A., Le Bocq, A., Nazarkina, L., & Hauschild, M. (2008). Methodologies for social life cycle assessment. *The international journal of life cycle assessment*, *13*(2), 96.

Kozlowski, A., Bardecki, M., & Searcy, C. (2012). Environmental impacts in the fashion industry: A life-cycle and stakeholder framework. *The Journal of Corporate Citizenship*, (45), 17.

Lamming, R., & Hampson, J. (1996). The environment as a supply chain management issue. *British journal of Management*, *7*(s1), S45-S62.

Lozano, R. (2012). Towards better embedding sustainability into companies' systems: an analysis of voluntary corporate initiatives. *Journal of Cleaner Production*, *25*, 14-26.

Luz, C. (2007). Waste couture: environmental impact of the clothing industry. *Environmental Health Perspectives*, *115*(9), A448.

Matten, D. and Crane, A. (2005). 'Corporate citizenship: towards an extended theoretical conceptualization'. Academy of Management Review, 30, 166–79
McKenzie, S. (2004). Social sustainability: towards some definitions.

Noordhollands Dagblad. (2017). Minder dan een fooi. [Newspaper article]. Woensdag 22 februari 2017 Nexis. Web. Date Accessed: 2017/05/17.

The Daily Telegraph (2013). Dozens killed as Bangladeshi clothes factory that supplies UK stores collapses." (London). April 25, 2013 Thursday. [Newspaper article]. Retrieved from: www.lexisnexis.com/uk/nexis, last visited on 19-06-2017.

Pfohl, H. C., Köhler, H., & Thomas, D. (2010). State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice. *Logistics research*, *2*(1), 33-44.

Pesonen, H. (2001). Environmental management of value chains. *Greener Management International, 33,* 45-58(14)

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E., ... & Nykvist, B. (2009). Planetary boundaries: exploring the safe operating space for humanity. *Ecology and society*, *14*(2).

Roos, S. (2016). *Advancing life cycle assessment of textile products to include textile chemicals. Inventory data and toxicity impact assessment* (Doctoral dissertation, Chalmers University of Technology).

Roos, S., Sandin, G., Zamani, B., & Peters, G. (2015). Environmental assessment of Swedish fashion consumption. *Five garments–sustainable futures. Mistra Future Fashion*.

Scherer, A. G., & Palazzo, G. (2011). The new political role of business in a globalized world: A review of a new perspective on CSR and its implications for the firm, governance, and democracy. *Journal of management studies*, *48*(4), 899-931.

Seuring, S., & Müller, M. (2008)[1]. From a literature review to a conceptual framework for sustainable supply chain management. *Journal of cleaner production*, *16*(15), 1699-1710.

Seuring, S., & Müller, M. (2008)[2]. Core issues in sustainable supply chain management–a Delphi study. *Business strategy and the environment*, *17*(8), 455-466.

Smith, S. (2013). Is Bangladesh's new minimum wage enough? [News article]. Ethical Trade Initiative. Retrieved from: http://www.ethicaltrade.org/blog/bangladeshs-new-minimum-wage-enough, last visited on 11-06-2017

Stranddorf, H. K., Hoffmann, L., & Schmidt, A. (2005). Impact categories, normalization and weighting in LCA. Danish Ministry of the Environment. *Environmental protection agency. Environmental news*, *78*.

Steinberger, J. K., Friot, D., Jolliet, O., & Erkman, S. (2009). A spatially explicit life cycle inventory of the global textile chain. *The International Journal of Life Cycle Assessment*, *14*(5), 443-455.

Steurer, R. (2013). Disentangling governance: a synoptic view of regulation by government, business and civil society. *Policy Sciences*, *46*(4), 387-410.

Thind, H. S., Buttar, G. S., & Aujla, M. S. (2010). Yield and water use efficiency of wheat and cotton under alternate furrow and check-basin irrigation with canal and tube well water in Punjab, India. *Irrigation science*, *28*(6), 489-496.

United Nations Environmental Programme (UNEP). (2015). Guidance on Organizational Life Cycle Assessment. [Report].

VanDuinen, M., Deisl, N. (2009). Handbook to Explain LCA Using the GaBi EDU Software Package. PE America LLC.

Varadarajan, G., & Venkatachalam, P. (2016). Sustainable textile dyeing processes. *Environmental chemistry letters*, *14*(1), 113-122.

WE Fashion. (2015). CSR Report 2014-2015. [Report].

Weidema, B. P. (2003). *Market information in life cycle assessment* (Vol. 863, p. 365). Miljøstyrelsen.

Weidema, B. P. (2006). The integration of economic and social aspects in life cycle impact assessment. The International Journal of Life Cycle Assessment,11, 89-96.

Welters, L. (2015). The fashion of sustainability. Sustainable Fashion: What's Next? A Conversation about Issues, Practices and Possibilities, 4.

Zamani, B., Sandin, G., Svanström, M., & Peters, G. M. (2016). Hotspot identification in the clothing industry using social life cycle assessment—opportunities and challenges of input-output modelling. The International Journal of Life Cycle Assessment, 1-11.

Zygmunt, J., Walker, G. (2008). Water and energy consumption of dishwashers and washing machines: an analysis of efficiencies to determine the possible need and options for a water efficiency label for wet white good. Waterwise, Londen. Retrieved from: http://www.waterwise.org.uk/data/2008_Waterwise_washing_machines_and_dishwashers.pdf

Appendix 1: CSR strategy pillars WE Fashion

WE Fashion's results of the 4 CSR strategy pillars 2014-2015. From the WE fashion CSR report 2014-2015.

RESULTS OF THE 4 CSR STRATEGY PILLARS 2014 - 2015

ACHIEVED TILL DEC 2015

- Not started
- Not achieved - stopped
- Started
- According to plan
- Achieved

TO BE ACHIEVED 2016

SUSTAINABLE SUPPLYCHAIN

1. IMPROVE SOCIAL CONDITIONS IN PRODUCTION
   - 1.1 Define the WE Fashion Code of Conduct for suppliers
   - 1.2 Create a score card for social performance of suppliers
   - 1.3 Ask suppliers to sign the WE Fashion Code of Conduct
   - 1.4 Supervise and approve supplier performance
   - 1.5 Evaluate and update the social suppliers management system
   - 1.6 Expand social suppliers management to lower levels in the supplychain
   - 1.7 Mapping the risks of labour rights in the supply chain
   - 1.8 Set up guidelines in relation to the sustainable purchasing of products
   - 1.9 Develop a complaints mechanism for the supply chain

2. IMPROVE THE LIVES OF WORKERS
   - 2.1 Actively participate in the Accord on Fire and Building Safety in Bangladesh
   - 2.2 Develop a roadmap for achieving a living wage

3. IMPROVE THE ENVIRONMENT IN PRODUCTION
   - 3.1 Enable suppliers to realise environmental improvements, via projects
   - 3.2 Reduce the use of water, energy and chemicals in production
   - 3.3 Develop a classification for the environmental performance of suppliers

BETTER PRODUCTS

4. USE MORE SUSTAINABLE MATERIALS
   - 4.1 Update our sustainable raw materials strategy
   - 4.2 Buy products made from sustainable materials
   - 4.3 Integrate Better Cotton into our collection
   - 4.4 Create a policy with respect to the use of animal materials
   - 4.5 Develop sustainable product labels
   - 4.6 Update supplier portal with regard to sustainable materials

- 4.7 Set up an eco-certification management system
- 4.8 Create a policy on sustainable leather
- 4.9 Develop a plan for the use of sustainable trimmings

5. MAKE ALL PRODUCT STAGES MORE SUSTAINABLE AND TRANSPARENT

- 5.1 Develop a plan tackling the use of hazardous chemical substances
- 5.2 Seek verification of our activities in the chain
- 5.3 Map products on the use of raw materials and treatments per order
- 5.4 Map out the wet processes used by WE Fashion (washing, dyeing)
- 5.5 Develop a wet processing strategy (washing, dyeing)
- 5.6 Measure the ecological footprint of the most important products
- 5.7 Give customers insight in which factories products are made

SUSTAINABLE OPERATIONS

6. INVEST IN OUR EMPLOYEES

- 6.1 Write a code of conduct for the WE Fashion employees
- 6.2 Measure CSR engagement among employees
- 6.3 Develop a CSR module for the WE Academy
- 6.4 Publish information in relation to all CSR guidelines internally
- 6.5 Launch and embrace CONNECT as a central value system

7. REDUCE WASTE

- 7.1 Reduce the number of plastic carrier bags handed out
- 7.2 Develop products made of recycled materials
- 7.3 Find suitable parties for various waste streams
- 7.4 Encourage reuse and recycling among customers
- 7.5 Write a plan to reduce product waste

8. REDUCE THE CO2 FOOTPRINT

- 8.1 Measure CO2 emissions
- 8.2 Introduce carelabels with savings tips in our clothes
- 8.3 Draw up a CO2 reduction plan for 2015-2020
- 8.4 Reduce the environmental impact of transport and logistics
- 8.5 Develop a policy for increasing the sustainability of non-commercial articles

COMMUNITY ENGAGEMENT

9. CHARITIES

- 9.1 Organise fund-raising activities
- 9.2 Draw up a Charity policy plan
- 9.3 Develop a volunteers programme for employees
- 9.4 Demonstrate tolerance via Get Together communication

Appendix 2: Survey in house and outsourced processes

This survey is about the **in house and outsourced processes** of the **boy's jeans.**

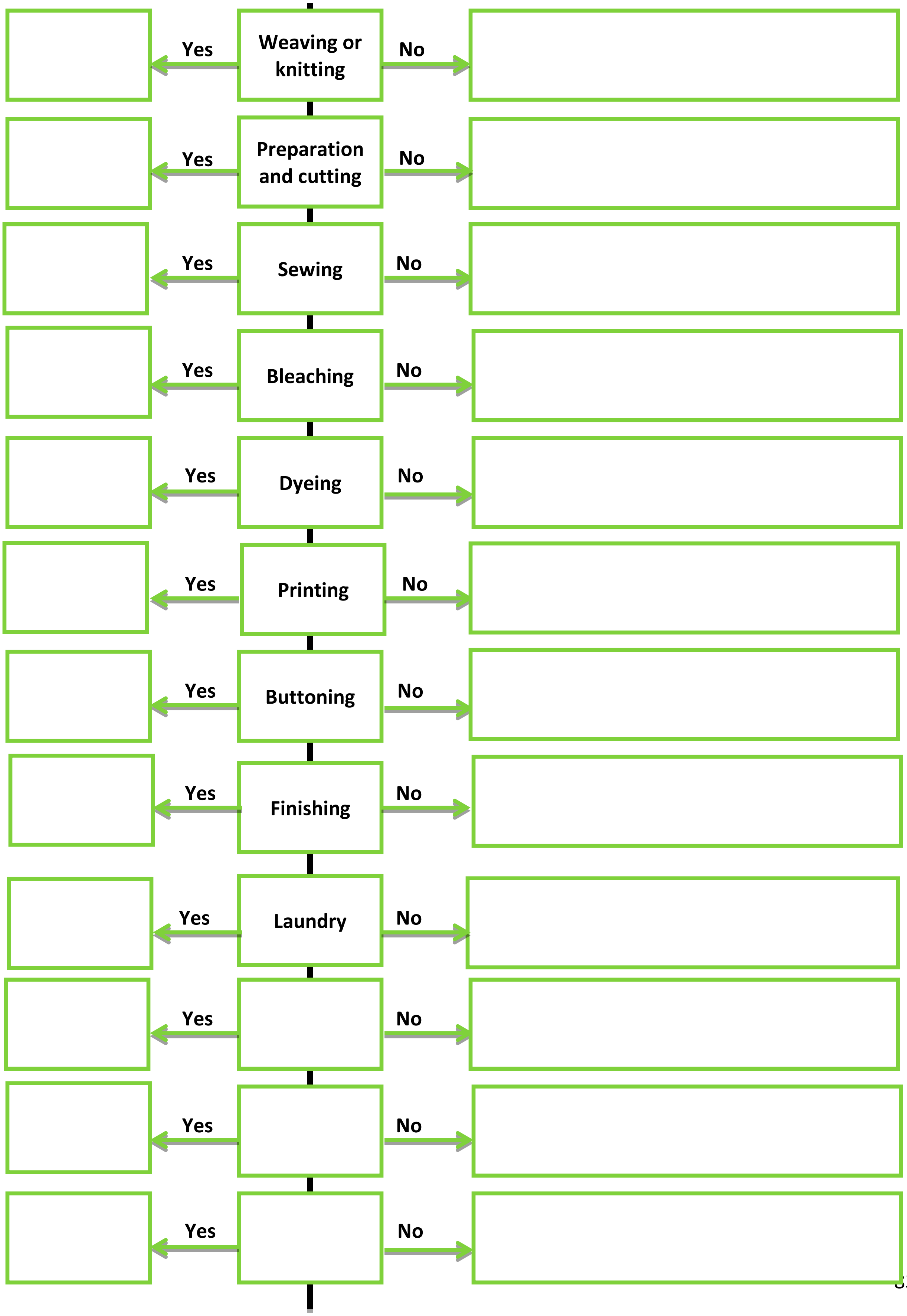
Firstly, please fill in below which trims are done in house and which ones are subcontracted. If they are done in house, please answer yes. If they are subcontracted, please fill in the name and contact details of the subcontractor. This information will only be used to send them a questionnaire as well, because we would like to collect information on all processes that are used to create the product. If possible, please also fill in the missing composition of the trims.

Trim	Composition	Done in house/subcontracted
Main material	99% cotton, 1 % elastane	
Lining	100% cotton	
Plastic buttons		
Metal buttons		
Elastic band		
Leather patch		

On the next page you will find a visualisation of a possible supply chain for these jeans. If a process is done in house, follow the arrow with " yes" and check the box. If a process is not done in house, follow the arrow with "no", to a box where you can fill in the name of the subcontractor. If a process is done both in house and at a subcontractor, please fill in both boxes. If a process is done twice or more, just fill in yes, I will come back to this in the follow-up survey. On the next page, some empty boxes are added for processes that miss from the list.

After filling in this form please send it back to me, so that I can send you the right questionnaire(s). If you have any questions or something is unclear, you can contact me at berber.de.haan@wefashion.com

In house? Please specify subcontractor is possible

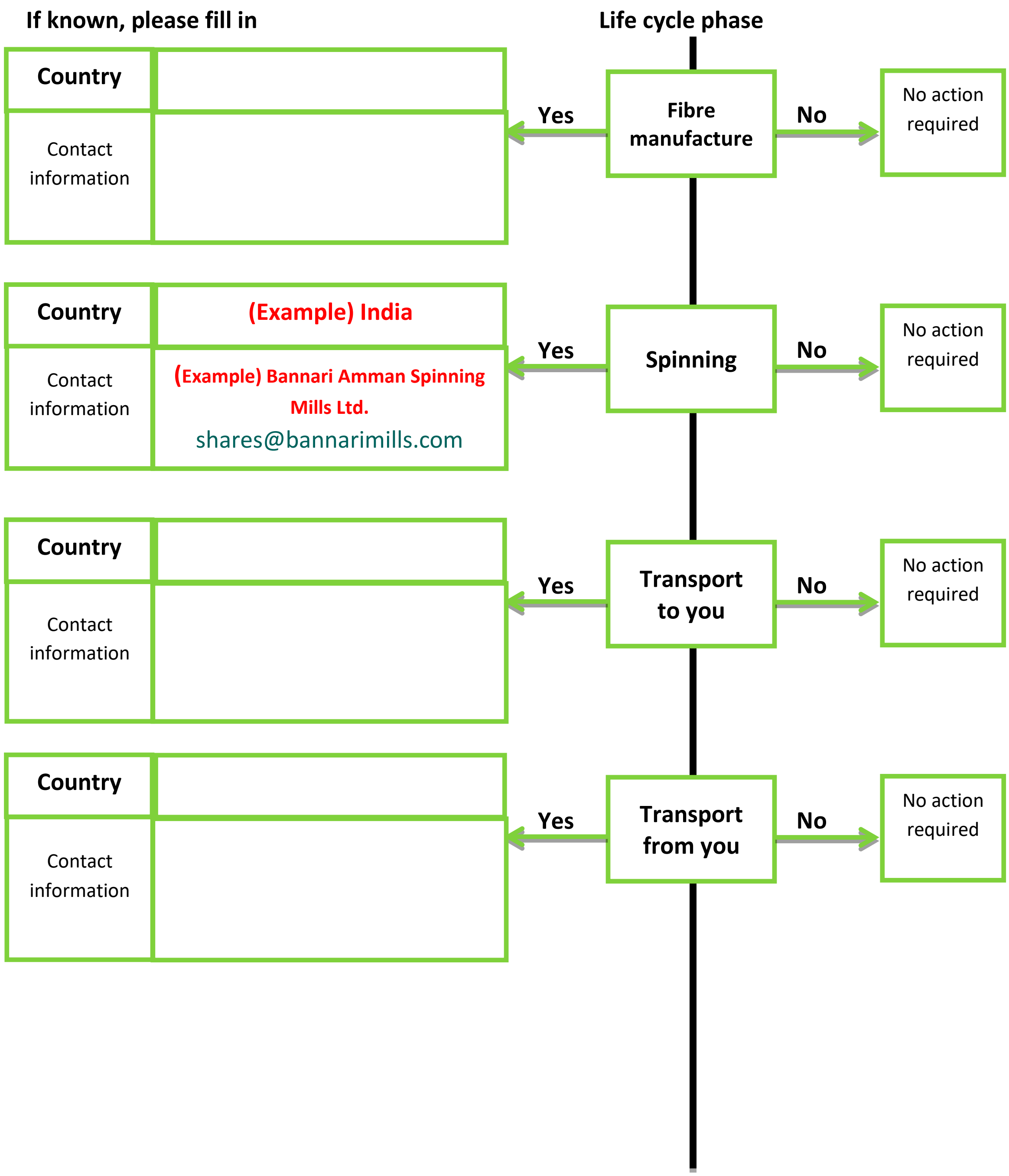


Appendix 3: Survey on the other life phases

This survey is about the **other life phases** of the **boy's jeans.**

Below is a visualization of possible life phases for these jeans. If you know in which country this phase takes place, please specify, if you also know which producer performs this process, please specify their contact information. If you do not know where a process takes place, no action is required. At the end there is an empty box added, in case any phase is missing.

After filling in this form please send it back to me. If you have any questions or something is unclear, you can contact me at berber.de.haan@wefashion.com



Appendix 4 . Data source specifics

Data source specifics boy's jeans

Life phase	Source	Comment/ information used
Cotton cultivation	EcoInvent database: - Cotton production, CN. GaBi build-in Database plan: - CH: electricity grid mix (production mix)	All inputs and outputs, calculated to fit weight of product
Elastane cultivation	GaBi build-in database flows: - Polyurethane resin [Plastic] - CN: electricity mix [production mix] - Elastane [non-renewable element]	Elastane only accounts for 1% of the composition so the influence of irregularities is minimal
Spinning	EDIPTEX Database on spinning. http://orbit.dtu.dk/files/7635219/EDIPTEX.pdf	Energy: 0.6 MJ/kg Water: 2.2 litres/kg
Weaving	EcoInvent database: - Textile production; woven cotton, GLO.	All inputs and outputs, calculated to weight of product
Bleaching	Survey results from direct supplier	
Dyeing	Not included in LCA	
Prep and cut	Survey results from direct supplier	
Sew	Survey results from direct supplier	
Lining production	GaBi build-in database: - Raw cotton [Materials from renewable raw materials]	Calculated to weight of lining
Plastic buttons	GaBi build-in database: - Polyester resin [unsaturated; UP) [Plastics]	Calculated to weight of plastic buttons
Elastane	GaBi build-in database: - Polyurethane resin [Plastic] - CN: electricity mix [production mix] - Elastane [non-renewable element]	Calculated to weight of elastane band
Metal buttons	GaBi build-in database: - Brass component [Metal parts]	Calculated to weight of metal buttons
Faux leather patch	GaBi build-in database: - PUR synthetic leather [synthetic leather]	Calculated to weight of leather patch
Adding lining	Transformation phase, no added inputs or outputs	
Finishing	Survey results from direct supplier	
Laundry	Survey results from direct supplier	
Transport	GaBi build-in database plan: - US: Transport, ocean freighter, diesel powered, USCLI	Based on a ocean freighter travelling from Bangladesh to Utrecht, approximately 12000 km.
Use	Electricity use, water use and water used estimated based on Zygmunt & Walker, 2008 GaBi build-in database: - NL: electricity, low voltage, at grid [production mix] - Washing liquids (23% aromates) [paint]	
Disposal	Land filling, no added impacts	