

TOWARDS A SUSTAINABLE SUPPLY CHAIN

*A collaboration strategy to improve
production processes and decrease
environmental impact in a fashion
supply chain.*

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Master thesis / May 2020

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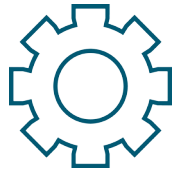
Towards a sustainable supply chain

A collaboration strategy to improve production processes and decrease environmental impact in a fashion supply chain.



marlies | dekkers

This thesis is structured in five sections:



This project

Information on the context and setup of this project.

Page 17-34



Discover

All research that is executed during this project.

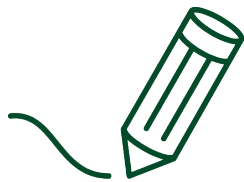
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Define

Synthesis of all research and the design requirements that were set up.

Page 69-84



Develop

The process of the development of the final outcome of this project.

Page 85-102



Deliver

Final results of this project.

Page 103-117

Tools to help you read this thesis:

Icons

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Pages

The page number on every section is in a colored box, corresponding with the colors of the sections.

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Conclusions

At the end of every chapter, the most important take-aways are written in a colored box, making it possible to quickly find the most important conclusions.



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Links

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Preface

This master thesis is the finalisation of my master programme in Strategic Product Design. Over the last months, I have been working to research environmental impacts in textile dyeing processes for marlies|dekkers, a Dutch lingerie brand. Furthermore, I have developed a collaboration strategy that provides opportunities to decrease these environmental impacts.

This thesis is divided in five sections. First, the context and setup of this project are explained. Second, all research and analyses that is executed is described. Third, the problem statement and design requirements are formulated. Fourth, the design process and proposed solution is described. Lastly, the final deliverable, a collaboration strategy that can lead to improved production processes to decrease the environmental impact of MD's supply chain, is elaborated.

I would like to thank marlies|dekkers for the opportunity to execute my master thesis at the company and to give me the opportunity to visit suppliers in China. This has been very valuable to the thesis and a great experience. Special thanks to my mentors, Miranda Martinez and Jetske Verbeek who coached me a lot during the process and to all people at the company who provided input, participated in the brainstorm session and helped me write this thesis.

Also, I would like to thank my supervisors at the TU Delft, Ellis van den Hende and Marcel Ludema, to take the time to read everything multiple times and provide helpful feedback.

Hopefully, this thesis contributes to solving the huge sustainability challenges that we face currently and in the future. I hope that starts by raising awareness about the ecological footprint of your fashion choices.

Henriëtte
Jeeuwen



Summary

Context & project setup

Sustainable production and consumption are becoming increasingly important to both consumers and businesses. Consumers are demanding more sustainable clothing and packaging, and are increasingly willing to pay for sustainable fashion. Business are looking for ways to respond to this.

Sustainability is defined as development that meets the needs of the present without compromising the ability of future generations to meet their needs. A distinction is made between social, environmental and financial sustainability.

The fashion industry has a significant impact on the environment, mostly because the textile industry relies heavily on non-renewable resources. When looking closer at the fashion supply chain, textile wet processing, which includes dyeing and printing of fabrics, contributes significantly to the environmental impact of the fashion industry by consuming and polluting significant amounts of water. Therefore, this thesis focuses on decreasing environmental impacts of textile wet processing for marlies|dekkers (MD).

It can be concluded that fashion supply chains are highly complex. A simple overview of a fashion supply chain is visualised in figure 1. Fashion supply chains are often shattered, causing a lack in traceability of fashion for both producers and consumers. This makes supply chain transparency challenging, as clarifying the sources of products is difficult for companies. Without transparency in the supply chain, it is very difficult to impact sustainability in the supply chain.

Supply chain integration contributes to successful supply chain management and can benefit the sustainability performances of all organisations involved. One form of supply chain integration is supply chain alignment. Aligning the social, environmental and economic goals in a supply chain, can improve the long-term performance of all organisations in that supply chain. A supply chain should be aligned in three ways: information accessibility, responsibilities and interests. In a successfully aligned supply chain, when organisations try to maximise their own performance, they contribute to a maximised supply chain performance. MD has not extensively aligned its supply chain yet nor is there a close integration with suppliers or customers.

The design challenge is formulated as follows:

How can marlies|dekkers collaborate with suppliers in its supply chain to decrease the environmental impact of its textile wet processes?

This design challenge is solved with the support of five research questions, which are answered by conducting literature research, carrying out interviews with tier 2 suppliers (see figure 1) and industry experts, conducting a survey among tier 2 suppliers, and organising brainstorm and input sessions with MD employees.

The research questions are defined as follows:

- 1| How can sustainability be managed in a garment production supply chain?
- 2| How is the current collaboration between MD and its tier 1 and tier 2 suppliers?
- 3| How can the environmental impact of textile wet processes be decreased?
- 4| How can MD strengthen the collaboration with its suppliers?
- 5| How can MD implement the collaboration strengthening solutions?

Textile wet processing in MD's supply chain is mainly located at tier 2 suppliers in China. During this research, input is gathered from MD employees, tier 2 suppliers in China and industry experts.

The final deliverable is a collaboration strategy, that can lead to improved production processes to decrease the environmental impact of MD's supply chain.

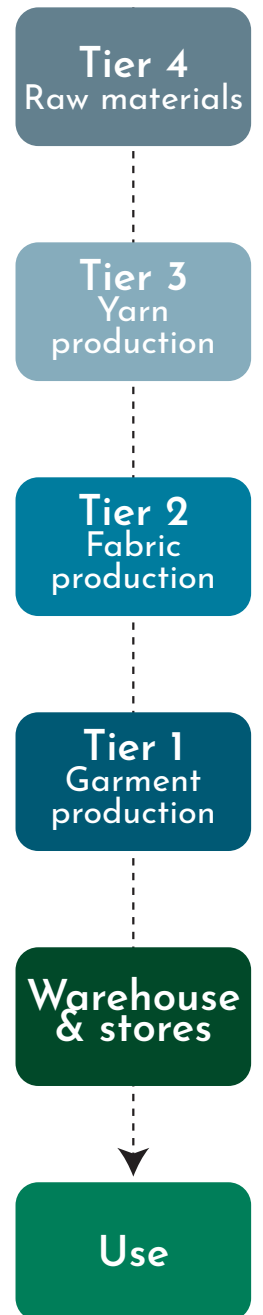


FIGURE 1. Simple overview of supply chain

H. Teeuwen

This thesis is structured using the double diamond, which consists of four phases, divided in two diamonds, visualised in figure 2. In the first phase, discover, the project is diverging; a lot of knowledge is gathered and analyses are performed to generate a comprehensive overview of the problem. Then, in the second phase, define, the project is converged. All results from the discover phase are converged to a set of design requirements, which will be the starting phase for the second diamond. In the third phase, develop, the project will diverge again, generating possible solutions to the problem. In the final phase, deliver, all solutions generated in the develop phase will converge to a final deliverable.

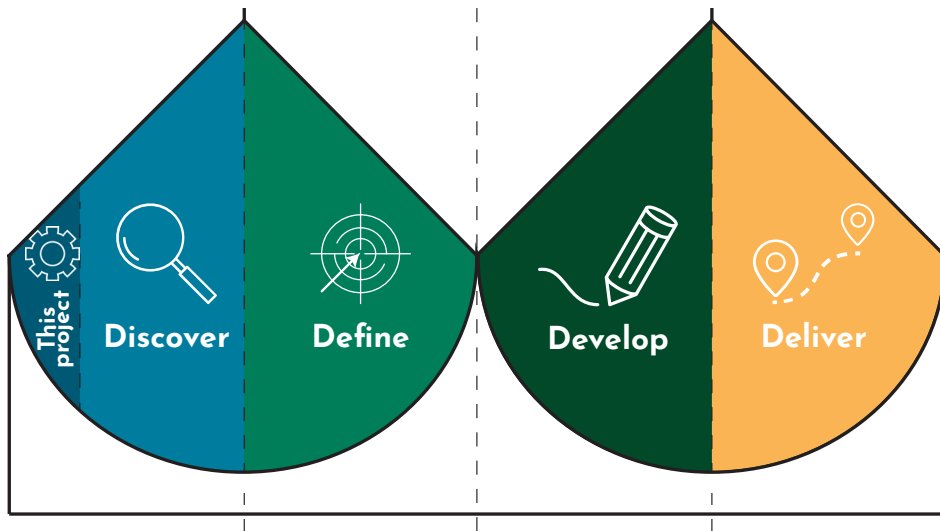


FIGURE 2. Double diamond

H. Teeuwen (based on DesignCouncil, 2007)

Discover

Fashion industry

Looking at the fashion industry, there are various coalitions, certifications and rankings present that aim to contribute to environmental sustainability. Coalitions unite various brands, companies and/or organisations to work towards a common goal. Certifications provide companies or consumers with information on (environmental) sustainability of companies, brands or products. Rankings compare multiple products or brands and rank them on sustainability practices.

All in all, measuring sustainability in the fashion industry is very complex, due to these many different coalitions, certifications and rankings.

However, not all industry marks are equally used or equally easy to use. Some certifications require coalition memberships and some industry marks are more expensive than others. This hampers determining the possible value of an industry mark.

Also, all marks have different goals. Some certifications are meant to inform customers, while others are mainly used by companies to manage their own performances. Also, some coalitions are networks of organisations, collaborating to achieve a certain goal, while others are more an expression of committing to a goal individually. Having different goals also leads to different measurement methods, making it hard to compare organisations on sustainability performances.

Lastly, not all marks are as relevant to all organisations or at all times. For example, some certifications need to be obtained every year, and hence they are quite up to date, while others might be outdated.

Taking all this into account, the reliability and validity of industry marks varies. Because of the overall complexity of industry marks, the reliability and validity is in any way questionable. Depending on the organisation, however, the industry marks can be useful for specific purposes. MD does not use many industry marks, but the ones currently used help the company execute its sustainability strategy.

For the competitor analysis, multiple competitors of MD, in different price ranges, are scored on transparency, environmental sustainability and social sustainability. This scoring is based on competitors' websites and (sustainability) reports. Looking at competitors' sustainability performances, MD scores well in its price range. Some (larger) companies in lower price ranges are also scoring well on sustainability.

It is undeniable that transparency in a supply chain is important to achieve sustainability, competitors that are more transparent are often perceived as more sustainable. Many well-performing competitors collaborate with various organisations that help them execute their sustainability strategy. Also, many well-performing competitors have set up collaborations with suppliers to improve sustainability. Collaborations with suppliers and other organisations could be an opportunity to help improve sustainability in MD's supply chain, since it can contribute to supply chain integration and alignment. However,

MD is not comparable with these competitors, since it is a much smaller company, which should be taken into account when setting up a collaboration.

Supply chain

As many fashion supply chains, MD's supply chain is complex and shattered. A simple overview of MD's supply chain is shown before in figure 1. In MD's supply chain, traceability and transparency in tier 3 and tier 4 are lacking. Furthermore, the product itself increases complexity in the supply chain, as lingerie consists of many different parts that require different production processes.

Textile wet processing, that this thesis focuses on, is, with exception of accessories, used in almost all product parts. The cost of textile wet processing only account for approximately 2,5% of the consumer price, while the environmental impact is probably much higher. This means that investing in sustainable textile wet processing could have a relatively high impact on the sustainability of MD's products, while having a relatively low impact on the price of MD's products.

91,2% of tier 1 and tier 2 suppliers is located in China (including Hong Kong). Of the Chinese suppliers, 72,5% is located in Guangdong, a province in the south. The fact that so many suppliers are located relatively close to each other, makes it easier for MD to manage supplier relations.

MD has outsourced many activities. One important activity is the quality control, that is outsourced to a local partner in Hong Kong, providing some significant advantages for MD. One advantage, and the main reason of outsourcing quality control to the local partner, is that it optimises the production process. Because this partner is located near the suppliers, in the same time zone, communication is easier and faster. Also, the partner can check samples faster and samples have to travel less distance to be checked.

Company analysis

MD is committed to improving sustainability in its supply chain. However, to decrease environmental impacts in the supply chain, MD has to impact the activities of tier 1 and tier 2 suppliers. MD currently uses five tier 1 suppliers (of which three are significantly more important). For textile wet processing in China, MD uses twenty different tier 2 suppliers.

Regarding the relations with tier 1 suppliers, two remarks must be made. First, MD has little leverage at those suppliers due to their size and the size of its

orders. Despite the little leverage, MD has a good and close collaboration with tier 1 suppliers. A good example of this collaboration is MD's code of conduct. With the signing of this document, all tier 1 suppliers commit to, amongst other things, sourcing sustainable materials and receiving OEKO-TEX compliance.

Looking at tier 2 supplier relations, MD uses "nominated suppliers". These are tier 2 suppliers that MD strongly recommends or even requires to the tier 1 suppliers. Among them, there are eight fabric suppliers responsible for dyeing or printing fabrics MD uses. With the nominated suppliers, MD has cultivated a long term relationship. Also, these suppliers are often used, all nominated tier 2 suppliers supply to at least three (out of five) of the tier 1 suppliers. This provides opportunities to collaborate. However, with other tier 2 suppliers, MD has an indirect or non-existent relationship. This limits MD to impact these business.

Textile wet processing

Textile wet processing consists of multiple processes, including pretreatment, dyeing, printing, setting, finishing, coating and washing. The order in which processes are executed can vary according to the desired results, and not all processes are always needed.

Textile wet processing has a high impact on the environment. It uses a significant amount of fresh water and generates a lot of polluted wastewater, that is often discarded in clean water sources. This way, the process pollutes even more water than it uses. Water pollution in textile wet processing is mainly caused by the release of chemicals and microfibers in the water. Energy usage, often generated by burning fossil fuels, and air pollution are other negative impacts on the environment, although they are less significant than the water related issues.

It can be concluded that dyeing and printing processes contribute a lot to the harmful impact of textile wet processing. There are some sustainable developments in textile wet processing that could provide solutions to the aforementioned environmental issues. For example, dyeing methods that use CO₂ to adhere the dyestuff to the fabric are a promising development. Also, dope dyeing, where yarn is dyed before it is woven or knitted as opposed to dyeing knitted or woven fabrics, could possibly decrease environmental impacts significantly.

Supplier research

During a supplier visit in China, four tier 2 suppliers were visited and interviewed. Besides, a survey was sent to 19 suppliers, of which 7 completed the survey. Both the interviews as the survey provide insights in supplier collaborations and sustainability practices of suppliers.

Most suppliers are investing in sustainable developments, however the incentive to do so, is either strict Chinese regulations, demand from (large) customers, or both. The Chinese regulation is expected to become more strict in the coming years, which might support sustainability improvements at tier 2 suppliers. Furthermore, suppliers are looking for ways to learn from each other and exchange knowledge. Some tier 2 suppliers already set up collaborations with tier 1 suppliers or brands to collaboratively improve sustainability.

All questioned suppliers have their own water treatment system to clean water after textile wet processing. All suppliers measure water consumption and energy consumption, 10 suppliers (of 11 respondents) measure chemical consumption. However, the metrics used differ per supplier and the results vary widely. The reliability and validity of these quantitative results are therefore questionable. This also increases the complexity in the supply chain and the possibilities for MD to measure and decrease environmental impact in the supply chain.

Define

Industry expert interviews

To deepen knowledge on the context, industry experts from four organisations are interviewed:

- ◊ Solidaridad (a civil society organisation that initiates and guides sustainability projects worldwide, such as the Better Mill initiative, targeting 75 Chinese textile mills to improve sustainability);
- ◊ A company that develops CO₂ dyeing technology;
- ◊ A tier 2 supplier that uses dope dyeing;
- ◊ A tier 3 supplier that supplies chemicals and dyestuff.

The industry experts provided useful insights on mainly three topics; CO₂ dyeing, dope dyeing and collaborating with suppliers.

Regarding CO₂ dyeing, it can be concluded that this is not (yet) viable or relevant for MD. It is not widely available, too expensive due to high investment cost and not possible with fabrics used by MD.

Dope dyeing could be an interesting opportunity, however it is not completely clear what the actual environmental impacts of dope dyeing are. Furthermore, it would only be desirable for standard colours, since developing other colours demands higher minimum orders and longer lead times.

The expert interviews provided three interesting insights in collaborating with suppliers. First, collaborations with tier 3 suppliers could be valuable. Tier 3 suppliers have specific knowledge on environmental impacts of textile wet processing and could provide insights in possible resource consumption. Second, even though sustainability is often associated as costly by tier 1 and tier 2 suppliers, the most evident way to increase sustainability is to reduce resource consumption, leading to cost reduction. By focusing on reducing resource consumption, suppliers could be engaged in a sustainability project. Last, to be able to commit suppliers for a long term project, it is important to organise meetings regularly to discuss progress and control the project.

Problem statement

After the discover phase, all analyses is synthesised to define the problem statement.

In the ideal situation, a sustainable supply chain would go without saying. All MD suppliers would be committed to produce products as sustainable as possible, progress would be measured with standardised measures and either consumers would be willing to pay for sustainable lingerie or suppliers would find ways to be sustainable without a significant increase in price. Furthermore, the supply chain would be fully transparent and all knowledge and expertise would be shared between suppliers. However, in reality, there are four main issues hampering the ideal situation:

- ◊ MD suppliers seem to be mainly driven by money. Other than cost reduction or force by legislation, suppliers have no incentives to improve sustainability. MD has too little leverage to force suppliers to improve;
- ◊ Often, but not necessarily, sustainability improvements cost money or require large investments in the short term. Therefore, it is often associated with expensive and costly;
- ◊ Textile wet processing, and the fashion industry in general, is complex. There are little standardised measurement methods and technical expertise is needed to fully understand, manage and improve these processes;

- ◊ The supply chain is not transparent and there is little alignment. MD does not know who its tier 3 and tier 4 suppliers are and tier 1 and tier 2 suppliers do not share any information or expertise with each other.

These issues have consequences that lead to the following definition of the problem statement:

Due to the complexity of the production process, the lack of transparency in the supply chain and the absence of collaboration and communication between suppliers, MD can hardly improve the sustainability of the production process.

From this problem statement, the solution space used in the develop phase is defined as:

A network of suppliers that enables them to share knowledge and expertise and collaborate on sustainability improvements.

Design requirements

Based on all analyses and on the problem statement, design requirements are set up that the final strategy must comply with:

The developed strategy should...

- ◊ contribute to MD's key ambitions;
- ◊ contribute to transparency in the supply chain;
- ◊ create internal and external support for sustainable development;
- ◊ make sure that possible agreements between MD and suppliers are complied with;
- ◊ contribute to alignment in the supply chain (between MD, tier 1 suppliers and tier 2 suppliers) regarding:
 - 1| information accessibility;
 - 2| responsibilities;
 - 3| interests;
- ◊ in no way harm social sustainability;
- ◊ group and unite tier 2 suppliers;
- ◊ be relevant to MD, taking the size of the business into account;
- ◊ be relevant to suppliers.

These requirements are used to evaluate the final solution.

Develop

Ideation

During the develop phase, a brainstorm with MD employees was organised to generate input and inspiration for the design phase. From this brainstorm, various inspirational ideas, solutions and risks emerged.

With the results of the brainstorm and the aforementioned problem statement, seven problems are defined that the network should overcome:

- 1| Due to the complexity of the process, it is not clear how sustainability should be measured;
- 2| Due to the lack of transparency, MD does not know who its tier 3 and tier 4 suppliers are and cannot know how sustainable production processes at those suppliers are;
- 3| There is little collaboration and communication between MD's suppliers. All suppliers have a lot of knowledge and expertise that is not shared;
- 4| Developing a network costs resources, mainly money and time. Since MD is a relatively small brand, MD does not have the resources to make large investments;
- 5| Suppliers should be committed to the network to make it successful. However, the main driver for suppliers is profit, and hence, the main driver to participate in such a project should be cost reduction;
- 6| Cultural differences might hamper the network, if the network is fully dependent on MD, since managing this network would be difficult for MD. Also, there is a risk of misunderstanding and misalignment;
- 7| Abuse of the network might hamper the sustainability goals, so prevention and control are needed.

Conceptualisation

A collaboration model is designed and proposed to tackle all aforementioned problems. The final concept of this model is visualised in figure 3 on page 11. In the final situation, MD would connect tier 1, tier 2 and tier 3 suppliers in a network. Furthermore, a local organisation supports the network, but the network is mainly carried by suppliers. MD could consider to include customers, consumers or other brands (and their suppliers) in the network. figure 3 visualises the final phase of the network, but it is proposed to set up the network in three phases.

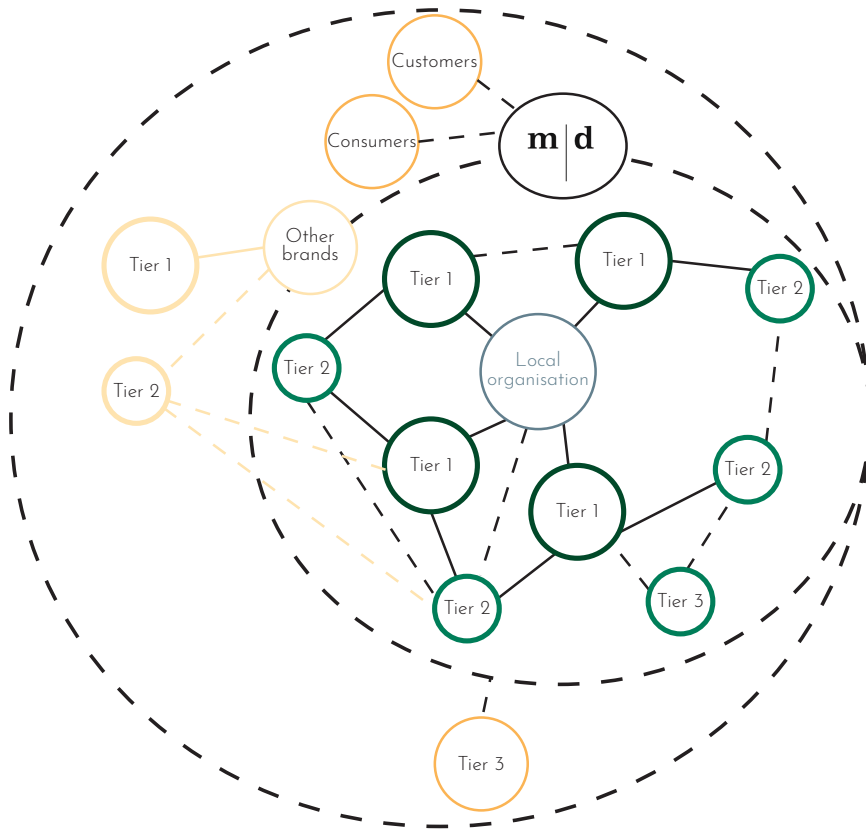


FIGURE 3. Final concept

H. Teeuwen

During the first phase, MD collaborates with a tier 3 supplier to commit tier 1 and tier 2 suppliers to reduce resource consumption. During the second phase, a local organisation supports the network and the network is further extended, connecting more suppliers. During the last phase, the network is carried by suppliers.

Impact measurement

To be able to define the impact MD makes by developing this network, the impact value chain is used. This model shows in five stages how impact is made. Starting at the end, there should be an aligned goal that all stakeholders are committed to. The outcomes describe the ultimate changes that one is trying to make in the world. The outputs are measurable, quantitative results. The activities are the primary actions that stakeholders must take. Last, the input describes all resources that stakeholders should invest. The most important inputs, activities, outputs, outcomes for suppliers and the aligned goal are visualised in figure 4 on page 12.

Deliver

Roadmap

A roadmap for the collaboration strategy was delivered.

The roadmap visualises different elements, such as industry developments, collaborations and technology developments on a timeline to make the collaboration strategy more tangible.

Implementation

Developing the aforementioned network is a project that is a part of and supports the sustainability strategy. A detailed implementation plan describes all activities that must be undertaken to develop the network. Every phase of developing the network should be executed along the five stages of project management; define, plan, execute, control and close. The most important activities during implementation are (progress) meetings with participating suppliers to discuss and control progress.

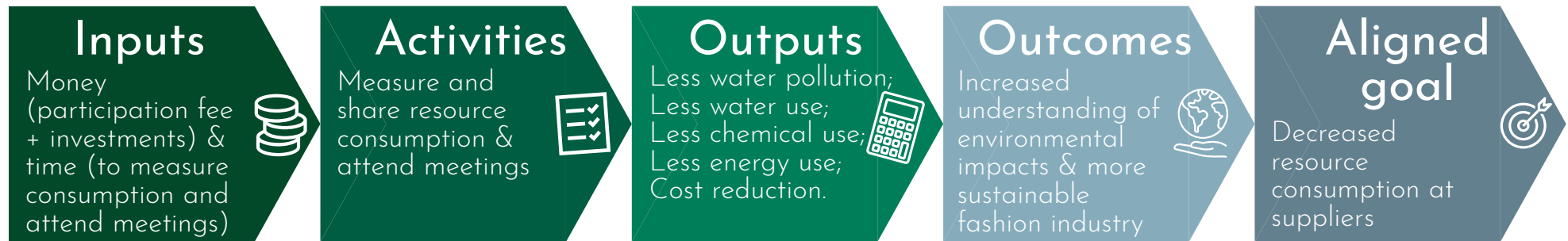


FIGURE 4. Impact value chain suppliers

H. Teeuwen (based on Clark et al., 2004)

Conclusion

The final concept of the collaboration model, the roadmap of the sustainability strategy and the implementation plan together form the final deliverable that was defined as:

A collaboration strategy, that can lead to improved production processes to decrease the environmental impact of MD's supply chain.

The deliverable is evaluated on the design requirements and on feasibility, viability and desirability.

The final concept complies with all design requirements that were set up.

Regarding feasibility, how realistic the solution is, two factors contribute to this. First, collaborations with a tier 3 suppliers and a local organisation contribute to supplier commitment and decrease the resources that MD needs to invest. Setting up the network with suppliers, making them partly responsible, also contributes to the feasibility.

Regarding viability, the ability of the solution to survive on the long term, two factors contribute to this. First, aligning the goal of developing this network with all stakeholders increases chances of success. Second, by developing it over time, communications and collaborations between suppliers have a chance to become an integrated part of these relationships.

Regarding desirability, how the proposed solution addresses the needs of all stakeholders included, it can be concluded that the network addresses the different needs of different stakeholders in different ways.

Discussion

Two discussion points and three limitations to the project are described.

First, executing a project as proposed by this thesis, would increase supply chain integration, which contributes to successful supply chain management. A more integrated supply chain however, means that a company depends more heavily on its suppliers, which is not always preferably, as the recent Covid-19 outbreak has shown. Even though integration is a good thing, companies might want to consider how dependent they are on specific suppliers.

Second, the final concept is partly developed on the basis of the design requirements. Probably, more broadly or more specifically formulated design requirements could have led to other results.

The first limitation to the project is the fact that the validity and reliability of the quantitative data from the supplier research is questionable, hampering the value of these results.

Second, the scope of the project was defined quite broadly. If the scope was set more narrow earlier in the process, probably a more tangible result could be delivered.

Third, the validation of the final strategy could not be done properly because during the last phase of writing this thesis, due to the outbreak of the Covid-19 virus.

Recommendations

Recommendations from three perspectives are proposed. First, recommendations to MD are described. Second, scientific recommendations for further research are proposed. Last, recommendations for interfaculty research are described.

For MD, the following six recommendations are proposed:

- ◊ Since the consumer phase also has a significant environmental impact, it is recommended to take this into account when tackling sustainability issues;
- ◊ Since digital printing is significantly less harmful to the environment than screen printing, MD could commit to use more digital printing;
- ◊ It is recommended to investigate the possibilities of using recycled fabrics;
- ◊ When thoroughly analysing environmental impacts in the supply chain, it is recommended to do so in collaboration with an organisation that has the expertise needed;
- ◊ When implementing the network, it could be valuable to include project assurance;
- ◊ MD could consider to apply for funding to execute this project.

Three recommendations for further research can be formulated:

- ◊ Further research to better map the garment supply chain, tackling the problem of complexity would be valuable;
- ◊ It would be valuable to research how environmental impacts could be measured by companies;
- ◊ Further research on social sustainability would be valuable.

Last, a recommendation regarding interfaculty research can be formulated. This thesis contributes to interfaculty research between the faculty of Industrial Design Engineering and the faculty of Technology, Policy and Management. Interfaculty research can be valuable, because it provides a more holistic view to a problem. I do believe that the solution that was presented in this thesis would probably not have emerged if the project was executed at one faculty. In the future, I would suggest that with every research, the researchers ask themselves whether an interfaculty research could be valuable.

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*Some chapters contain confidential client information and are therefore not fully published.
Also, the appendices are not published.*

PART I

This project

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1 Context

This chapter provides background information on the context of the project through a literature study. First, sustainability in general is discussed, followed by sustainability in the fashion industry. Sustainability issues in textile wet processes, dyeing and printing of fabrics, are explained. Finally, managing sustainability in a fashion supply chain is discussed.



1|1 Sustainability

Over the last decades, the topic of sustainability received increasing attention amongst consumers, politicians and companies. Consumers and companies have rising concerns about their impact on the environment and are looking for ways to alleviate this impact (McKinsey&Company, 2019). Sustainable consumption and production is becoming more and more important on the sustainable development agenda (Dissanayake & Sinha, 2010).

Consumers

According to Shen (2014), consumers are increasingly interested in purchasing eco-fashion and are willing to pay for it. A study by Eastman (2018) amongst 5,000 men and women, ages 13-60, in the U.S., U.K., Germany, Italy and China in 2018 showed that 14% of consumers identify themselves as “sustainable shoppers”, always buying sustainable apparel for premium prices. Furthermore, 26% of the consumers are “semi/sustainable shoppers”, who seek out to buy sustainable apparel but are currently unwilling to pay a premium price (Eastman, 2018). The results of this study are shown in figure 5. Furthermore, this research showed that sustainable shoppers are three times more likely to check eco-policies of the companies they buy from, compared to other global consumers. Also, they spend 57% more on apparel and are 74% more likely to buy apparel from a brand that offers education on sustainability initiatives (Eastman, 2018).

A study from 2018 shows that to 57% of consumers, sustainability is a criteria to purchase apparel (TechnoFashionWorld, 2018).

A market research executed by MD amongst 2100 consumers showed that 14% of MD's consumers demanded eco-friendly packaging (Petkov, 2019¹). This indicates that at least 14% of MD's consumers find sustainability important.

Definition of sustainability

While sustainability is thus an important issue to consumers and industries, the definition of sustainability is complex. The most comprehensive definition of sustainability is given by the World Commission on Environment and Development (World Commission on Environment and Development, 1987):

“Sustainability is development that meets the needs of the present without compromising the ability of future generations to meet their needs.”

¹ Source from MD's intranet (not publicly accessible)

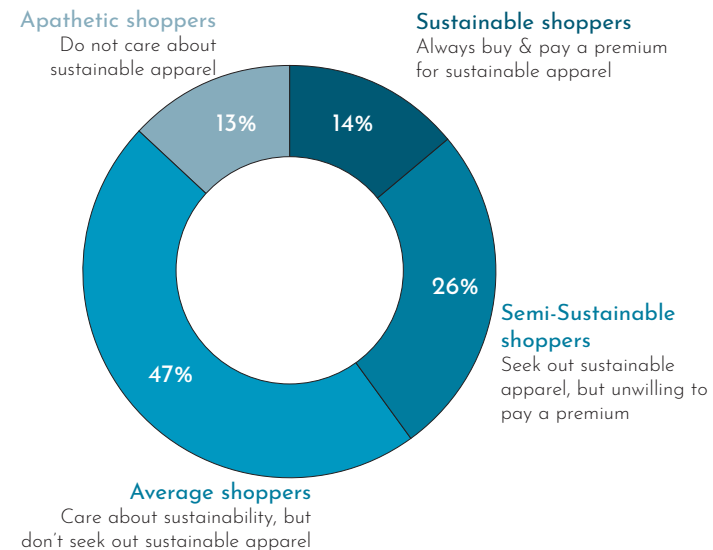


FIGURE 5. Sustainable consumers

(H. Teeuwen, based on Eastman, 2018)

Carter & Rogers (2008, p. 368) defined sustainability more specifically as “the strategic, transparent integration and achievement of an organization’s social, environmental, and economic goals in the systemic coordination of key inter-organisational business processes for improving the long-term economic performance of the individual company and its supply chains”. This definition mentions three aspects of sustainability: social, environmental and economical. In addition, for development to be sustainable, it must take social and ecological factors, as well as economic ones, into account (Moldan, Janoušková & Hák, 2012). This thesis focuses mainly on environmental factors of sustainability.

Environmental sustainability

According to Goodland (1995), “environmental sustainability seeks to improve human welfare by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded, in order to prevent harm to humans”. This relates to four major activities that define the level of environmental sustainability; use of renewable and non-renewable sources, pollution and waste assimilation (Holdren, Daily & Ehrlich, 1995). Sutton (2004) defines environmental sustainability as “the ability to maintain the qualities that are valued in the physical environment”.

Finally, these definitions are brought together in five objectives for enhancing cost-effective and operational environmental policies in the context of sustainable development:

- 1| “Maintaining the integrity of ecosystems through the efficient management of natural resources;
 - 2| De-coupling environmental pressures from economic growth;
 - 3| Improving information for decision-making: measuring progress through indicators;
 - 4| The social and environmental interface: enhancing quality of life;
 - 5| Global environmental interdependence: improving governance and co-operation.”
- (OECD, 2001)

These objectives summarise the most important aspects of environmental sustainability.

1|2 The fashion industry

Textile waste is identified as the fastest growing stream in household waste (Defra, 2007). The production of cotton alone needs 350.000 km² of land annually (approximately the size of Germany). Besides, the fashion industry uses 93 billion m³ of water yearly, that is 93.000.000.000.000 liters, enough for five million people to survive for a year. This represents 4% of global freshwater withdrawal and it does not even include the 20 billion m³ water that is needed to wash clothes in washing machines annually. Of all industrial water pollution globally, 20% is attributable to the dyeing and treatment of textiles (Ellen MacArthur Foundation, 2017).

The textile industry relies heavily on non-renewable resources (Huggard & Cope, 2020). Per year, 98 million tonnes of resources are used, including oil to produce synthetic fibres, fertilisers to grow cotton, and chemicals to produce, dye, and finish fibres and textiles. Moreover, in 2015, greenhouse gas emissions by the textile industry totalled 1.2 billion tonnes of CO₂ equivalent, more than those of all international flights and maritime shipping combined. (Ellen MacArthur Foundation, 2017; Fashion Revolution, 2019; TechnoFashionWorld, 2018). Concluding, the textile sector has a significant environmental impact on air pollution, greenhouse gas emissions, land use, water consumption, water pollution and waste (Manshoven et al., 2019).

Fashion can be characterised by its short life-cycle (Rivoli, 2014). In the UK, for example, the estimated average lifetime for a garment of clothing is only 2,2 years (Wrap, 2012). The fashion industry thus has a high volatility and a low predictability, as its consumers are characterised by high impulse purchasing (Dissanayake & Sinha, 2010).

Multiple sources mention that the fashion industry is the second most polluting industry in the world (Brenot et al., 2019; TechnoFashionWorld, 2018). However, how polluting an industry actually is, is quite complicated. There is a lack of reliable facts and data that are needed to validate which industries are more polluting than others (Global Fashion Agenda & The Boston Consulting Group, 2017). Furthermore, it is impossible to calculate the pollution of separate industries, because there is a lot of overlap (Wicker, 2019). For example, there is transportation in the fashion industry, cotton farming is both fashion industry and agriculture and the fashion industry uses energy provided by the energy industry.

Looking at water pollution, the wastewater from textile plants is classified as the most polluting of all the industrial sectors, considering the volume generated as well as the effluent composition (Drumond Chequer et al., 2013, p. 152). Because of that, the textile dyeing industry is the second largest polluter of clean water, after agriculture (Hanson, 2019; Kant, 2012; United Nations, 2018). However, this does not take other forms of pollution into account, such as greenhouse gas emissions.

All in all, these characteristics contribute to the environmental impact of the fashion industry. It cannot be said that fashion is the second most polluting industry in the world, but it is evident that the fashion industry is polluting and opportunities to improve exist (Global Fashion Agenda & The Boston Consulting Group, 2017).

1|3 Textile wet processes

The fashion supply chain can be roughly divided in six stages (Marlies|Dekkers, 2018; H&M Group, 2019; Stella McCartney, 2016). These stages are shown in figure 6 on page 21. Between every stage, transport takes place. However, in this figure, transport is only shown between tier 1 and sales, because this is the most significant transportation in terms of environmental impact in the supply chain, and because this transportation can be influenced by MD (Marlies|Dekkers, 2018; H&M Group, 2019).

Additionally, this figure shows MD's impact, the environmental impact and the social impact in the seven stages (Marlies|Dekkers, 2018). These are relative impacts, meaning that for example MD's impact in the transport phase is higher than the impact in tier 2, but lower than the impact in the sales phase. This data is estimated by MD and says nothing about the absolute impacts in the supply chain.

It is clear that the social and environmental impact is higher in tier 2, 3 and 4, whilst the impact MD has in these parts of the supply chain is lower. In the garment production, transport and sales phases, the environmental impact is relatively low. In the use phase, the environmental impact is higher, mainly because of two reasons. First, washing of clothes uses significant amounts of water and causes water pollution. Second, due to the relatively short life-cycle of fashion, the resources needed in the production phases contribute heavily to the environmental impact of fashion.

According to research by H&M Group (2019), the highest climate impacts are in tier 4, mostly due to cotton production, in tier 2, mostly due to textile dyeing, and during the use phase.

This thesis focuses on the fabric dyeing and printing processes, also referred to as textile wet processing. These processes mostly take place at tier 2 suppliers.

Textile wet processing is considered the most significant stage in terms of environmental emissions in the garment supply chain (Moazzem, Daver, Crossin & Wang, 2018). This is mainly due to three factors: greenhouse gas emissions, water consumption and water pollution. During the processes of textile fibre dyeing and finishing, the discharge of dyes in the water causes significant pollution (Pang & Abdullah, 2013; Raut, Gardas & Narkhede, 2019). Also, the textile chemical processing generates a large amount of wastewater (Nayak, Akbari, & Maleki Far, 2019).

It can be concluded that the textile wet processing phase has a significant impact on the environment through water consumption and water pollution. According to an Environmental Profit & Loss (EP&L) analysis executed by fashion brand Stella McCartney, tier 2 processes account for 12% of the total environmental impact of the garment production process (Stella McCartney, 2016). Furthermore, figure 7 shows the environmental impact of Stella McCartney's supply chain. It can be seen that greenhouse gas emissions, water consumption and water pollution together account for 57% of Stella McCartney's total environmental impact. Just looking at tier 2, these three

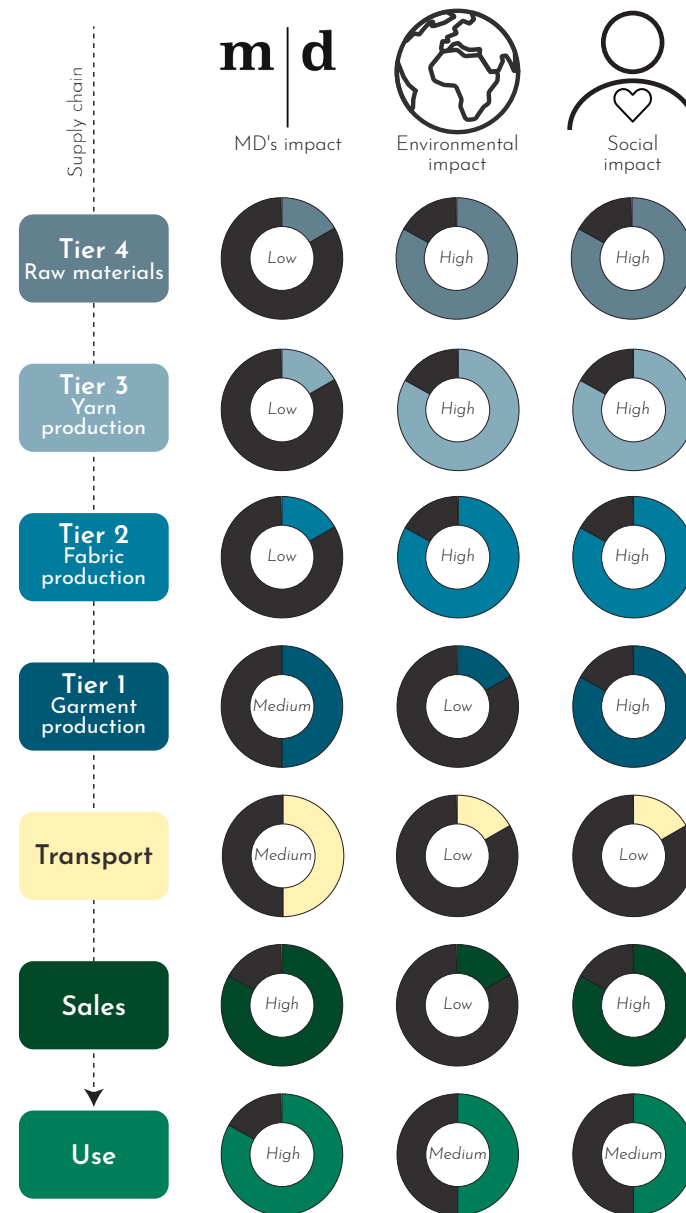


FIGURE 6. MD's impact in the fashion supply chain
(H. Teeuwen, based on Marlies|Dekkers, 2018)

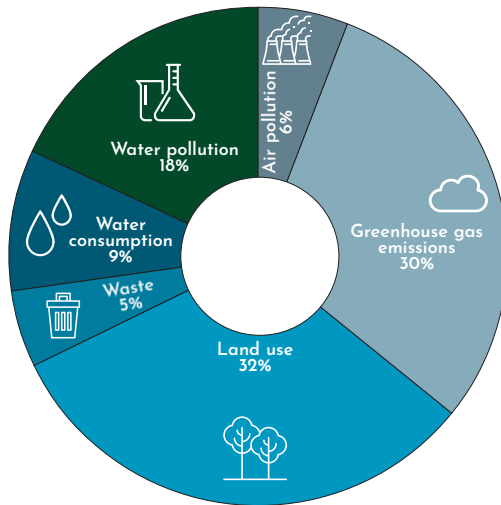


FIGURE 7. EP&L by Stella McCartney

(H. Teeuwen, based on Stella McCartney, 2016)

factors account for 64% of the total tier 2 impact (Stella McCartney, 2016). This means that the environmental impact of greenhouse gas emissions, water consumption and water pollution in tier 2 accounts for approximately 7.5% of Stella McCartney's total environmental impact.

1|4 Supply chain

Sustainable supply chain management

Seuring & Müller (2008, p.1700) define sustainable supply chain management as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development such as economic, environmental and social, into accounts which are derived from customer and stakeholder requirements." This includes the aforementioned three perspectives of sustainability, economic, social and environmental (Carter & Rogers, 2008; Moldan, Janoušková & Hák, 2012). It also implies that cooperation within the supply chain is important, as is also stated by Tay, Rahman, Aziz, & Sidek (2015). It is stated that focusing on supply chains contributes to the broader adoption and development of sustainability, since the supply chain considers the product from initial processing of raw materials to delivery to the end customer (Seuring, Sarkis, Müller, & Rao, 2008).

Traceability in garment supply chains

The supply chain described in figure 6 is a simplified representation of reality. In reality, the textile supply chain is much more complex, due to the fact that it is highly global and decentralised (Muthu, 2014). For example, MD has 6 tier 1 suppliers, approximately 60 tier 2 suppliers and not yet insight in the tier 3 and tier 4 suppliers. Looking into tier 3 and tier 4 suppliers, the production becomes more and more shattered and traceability in the supply chain becomes a challenge. Almost all fashion companies have difficulties providing insights in the traceability of their products in all tiers in the supply chain. Also, the textile production is dispersed around the world; materials may be sourced in South America, while the clothing may be stitched and cut in Asia and then sold in Europe and North America (Rivoli, 2014). This increases the complexity and traceability difficulties.

Transparency in garment supply chains

The lack of traceability in the textile supply chain leads to a lack of transparency. A t-shirt label that says "made in China" provides consumers with information on where the t-shirt is stitched. However, this label does not tell consumers anything about the production location of the fabrics, yarn and cotton used in the t-shirt. To tackle this problem, a global coalition of nine trade union federations and human rights organisations have developed the Transparency Pledge. The objective of this pledge, signed by multiple fashion companies including MD, is to help the garment industry reach a common minimum standard for supply chain disclosures. Companies that signed the pledge are expected to publish information on all suppliers in the manufacturing phase of their supply chains. The coalition strives to set a standard on transparency. More supply chain transparency is expected to increase environmental and social sustainability in the fashion supply chain (The Coalition, 2018).

Information about the origin and composition of clothing is important to identify and eliminate potential sustainability-related risks (Agrawal & Pal, 2019). More and more companies disclose their (tier 1 and tier 2) suppliers online, as consumers demand to access this information. MD is also doing well on transparency, by signing the transparency pledge and disclosing a list of tier 1 and tier 2 suppliers (Marlies|Dekkers, n.d., a)

Supply chain integration

The aforementioned supply chain decentralisation and lack of transparency and traceability cause a lack of supply chain integration. The integration of key business processes from end user through original suppliers contributes to successful supply chain management (Lambert, Cooper, & Pagh, 1998). Also, it is stated that supply chain integration will reduce the perceived risk between the buyer and the supplier as it increases the information flow in the supply chain (Cousins & Menguc, 2006).

Supply chain integration can happen in two ways, horizontal or vertical. Horizontal integration is an integration between supply chains, while vertical integration takes place within a supply chain, as visualised in figure 8. If MD would for example take over a competitor (with a different supply chain), horizontal integration takes place. On the other hand, vertical integration takes place if for example a tier 2 supplier decides to produce its own yarn and takes over a tier 3 supplier.

In vertical supply chain integration, a distinction is made between two forms of vertical integration. Forward integration refers to integration that is managed through the supply chain from the manufacturer to the consumer, while backward integration refers to the coordination of information flows from the consumer to the manufacturer (Trent, & Monczka, 1998). Sharing of consumer data on purchasing choices with suppliers is thus an example of backward vertical integration.

Joint ventures or weaker forms of partnerships between two companies are an example of less intensive supply chain integration (Lambert, Emmelhainz & Gardner, 1996).

The concept of supply chain integration becomes more important and relevant because it can have positive effects on businesses. Frohlich and Westbrook (2001) stress the importance of linking internal processes to external suppliers to create unique supply chains. Integrating operations at various stages in the textile supply chain could increase competitive advantages of textile supply chains significantly (De Brito & Van der Laan, 2010; Croxton, García-Dastugue, Lambert, & Rogers, 2001; Frohlich & Westbrook, 2001; Raut, Gardas & Narkhede, 2019).

Supply chains are competing against other supply chains, instead of individual firms competing against each other (Mouritsen, Skjøtt-Larsen & Kotzab, 2003; Koza & Lewin, 2000). As a result, the role of individual firms

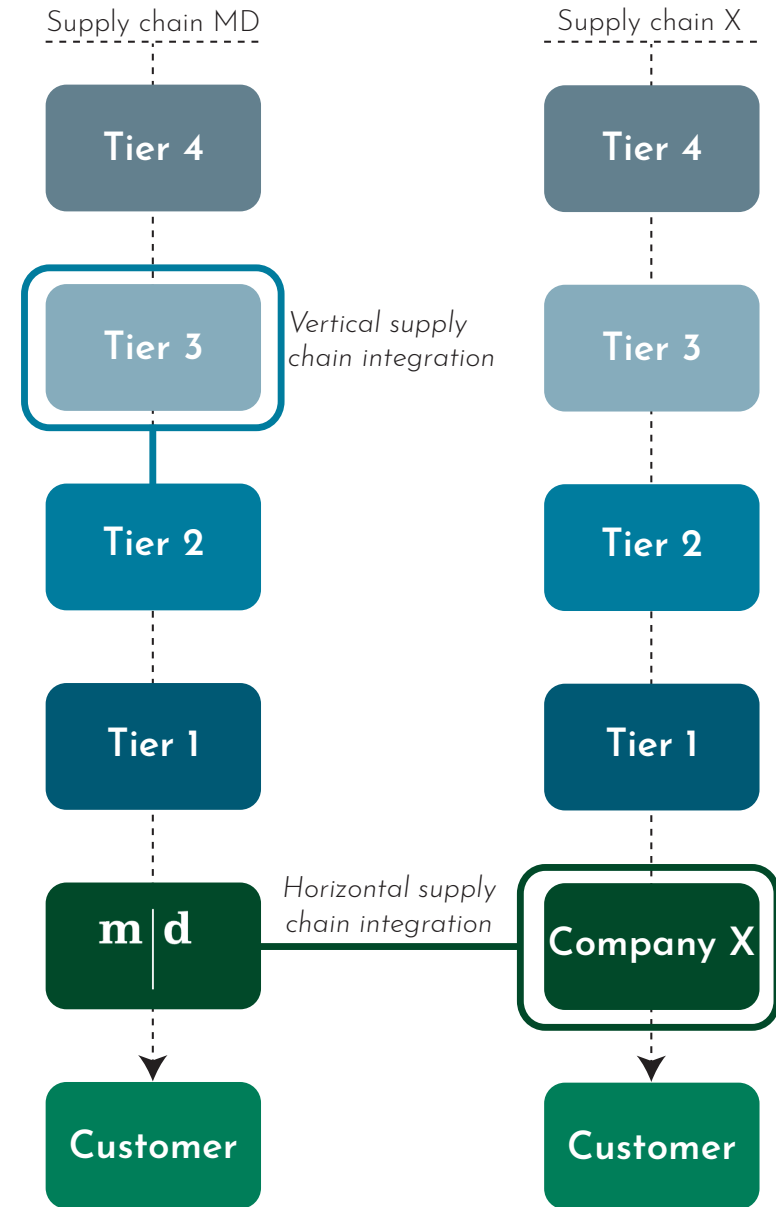


FIGURE 8. Horizontal vs vertical supply chain integration
(H. Teeuwen)

within a supply chain becomes subordinate to the role of the supply chain as a whole. The greatest opportunities to improve supply chains are often found in external supply chains and the interfaces between different organisations within this supply chain (Handfield & Nichols, 2002). Therefore, it is important to look beyond one organisation and take the entire value chain into account.

Integration is also important to improve sustainability within a supply chain. As mentioned, a definition of sustainability is “the strategic, transparent integration and achievement of an organisation’s social, environmental, and economic goals in the systemic coordination of key inter-organisational business processes for improving the long-term economic performance of the individual company and its supply chains” (Carter & Rogers, 2008). So, by aligning the social, environmental and economic goals in a supply chain, the long-term economic performance of all organisations in the supply chain can be improved.

Looking at supply chain integration; an important concept is the arc of integration, visualising a company’s strategic position with respect to supply chain integration development. The arc of integration shows in which direction a supply chain is integrating (towards customers and/or towards suppliers) and to what extent (Frohlich & Westbrook, 2001). In figure 9, possible arcs of integration for MD are shown. This does not show the current arc of integration but rather visualises the difference between a narrow and a broad arc of integration. Currently, MD has a relatively narrow arc of integration. For example, the integration is not extensive as it does not involve tier 2, 3 or 4 suppliers. Also, the little integration that might exist is not very intensive. MD and some tier 1 suppliers might have a quite superficial integration.

Supply chain integration exists on many levels. The examples mentioned before are forms of extensive supply chain integration, where two organisations merge to one. However, supply chain integration can also refer to less intense collaborations and alignments within a supply chain (Porter, 1998).

A less extensive form of supply chain integration is supply chain alignment: ensuring that all organisations within a supply chain try to improve the performance of the entire chain (Lee, 2004). A collaborative supply chain should be aligned in several ways. First, it is important to align information, so that all companies have equal access to for example sales data and forecasts. Second, identities of all organisations included should be aligned, meaning that roles and responsibilities are defined so that there is no room

for conflict. Third, interests and incentives should be aligned. This way, when organisations maximise their own performance, they also maximise the supply chain’s performance (Lee, 2004). This can lead to better forecasting, faster response on changing demands (Lee, 2004), more transparency and improved sustainability (Carter & Rogers, 2008). An example of a well-aligned supply chain is a Japanese company who has aligned its incentives with the incentives of its suppliers. Suppliers pay a penalty when they fail to deliver on time, but the company also helps its suppliers saving money by eliminating time-consuming delivery checks (Lee, 2004).

Currently, MD has reached supply chain alignment on some levels. With tier 1 suppliers, roles and responsibilities are defined clearly and some information is aligned.

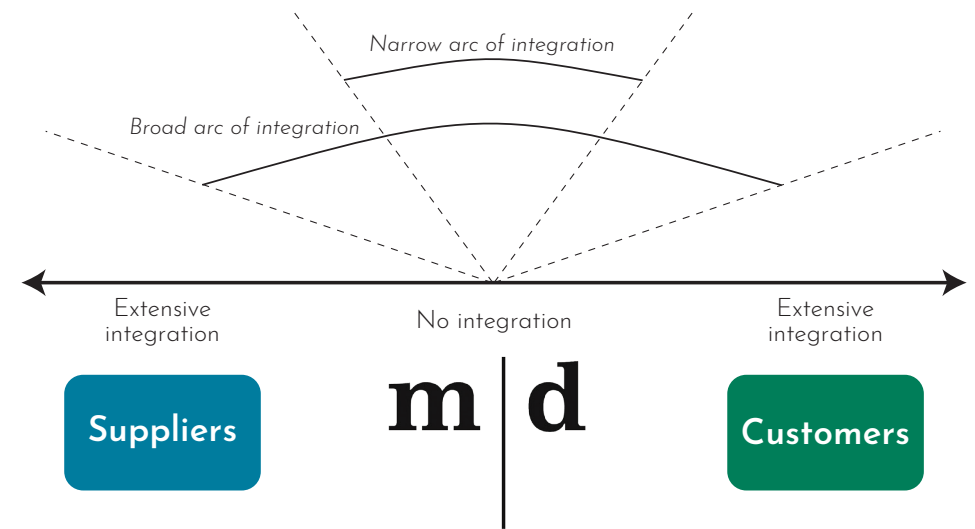


FIGURE 9. Arcs of integration

(H. Teeuwen, based on Frohlich & Westbrook, 2001)

1|5 Conclusions

Sustainable production and consumption are becoming increasingly important to both consumers and businesses. Consumers are demanding more sustainable clothing and packaging, and are increasingly willing to pay for sustainable fashion. Hence, businesses need to respond to this.

When looking at the fashion supply chain, textile wet processing, including dyeing and printing of fabrics, contributes significantly to the environmental impact of the fashion industry.

This thesis focuses on the environmental impact of textile wet processing.

The fashion supply chain is complex, causing a lack in traceability of fashion for both producers and consumers. This makes supply chain transparency challenging, as clarifying the sources of products is difficult for companies. Moreover, this lack of traceability leads to a lack of supply chain integration, which hampers improving the (environmental) sustainability in a supply chain.

An integrated fashion production supply chain can benefit the sustainability performances of all organisations involved. The arc of integration indicates to what extent an organisation is integrated with its supply chain. Currently, MD has a relatively narrow arc of integration, meaning that there is little to no integration with suppliers or customers.

One form of supply chain integration is supply chain alignment. Aligning the social, environmental and economic goals in a supply chain, can improve the long-term economic performance of all

organisations in that supply chain.

Successful alignment in a supply chain can lead to an improved performance of the entire chain. A supply chain should be aligned in three ways: information accessibility, responsibilities and interests. In a successfully aligned supply chain, when organisations try to maximise their own performance, they contribute to a maximised supply chain performance. MD has not extensively aligned its supply chain yet, although some alignment exists with tier 1 suppliers regarding information accessibility and the definition of roles and responsibilities.

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2 Setup

This chapter explains the setup of this project. First, the context in which this project is executed is explained. Then, the setup of the graduation project is presented. The design challenge and research questions are elaborated upon next. Lastly, the problem and its scope are defined.



2|1 Project client

This assignment is performed for Dare to Be bv, a Dutch company that sells the brand MarliesDekkers, hereafter abbreviated to MD. MD is a Dutch high-end designer brand in lingerie and swimwear.

This project is executed in the department of product and development. This department is responsible for the designs and production of all MD products. The focus of this graduation project is on sustainability of MD's production processes.

As explained, sustainability can be addressed from various perspectives: social, environmental and financial (Moldan et al., 2012). This project focuses mainly on the environmental sustainability of MD's supply chain. However, social and financial sustainability are kept in mind while designing environmentally sustainable solutions. To ensure that the designed solutions are also sustainable from a social and a financial perspective, employees from MD from different departments contribute to this thesis in various ways. Their expertise is used to validate intermediate and final results. Also, MD employees contributed to the development of the final deliverable by giving input in a brainstorm session. Furthermore, one employee at MD facilitated and joined the field research in China. Lastly, MD employees provided useful information throughout the project, for example on supplier management and on the strategy of MD.

As mentioned before, the fashion industry is highly polluting and sustainability is increasingly becoming a priority for companies to integrate in their strategies (McKinsey&Company, 2019). This is also the case for MD, which has integrated corporate social responsibility in the company's strategy and is currently aiming to work towards a sustainable business model (MarliesDekkers, 2018). In its strategy, MD has defined four key ambitions

(figure 10). Firstly, MD wants to be fair and equal by respecting human rights within the company and its supply chain. Secondly, the company is committed to find sustainable solutions in cooperation with experts in the industry. Thirdly, MD is transparent about its sustainability goals and steps taken. Lastly, its mission is to empower women and spread the feminine feminist message.

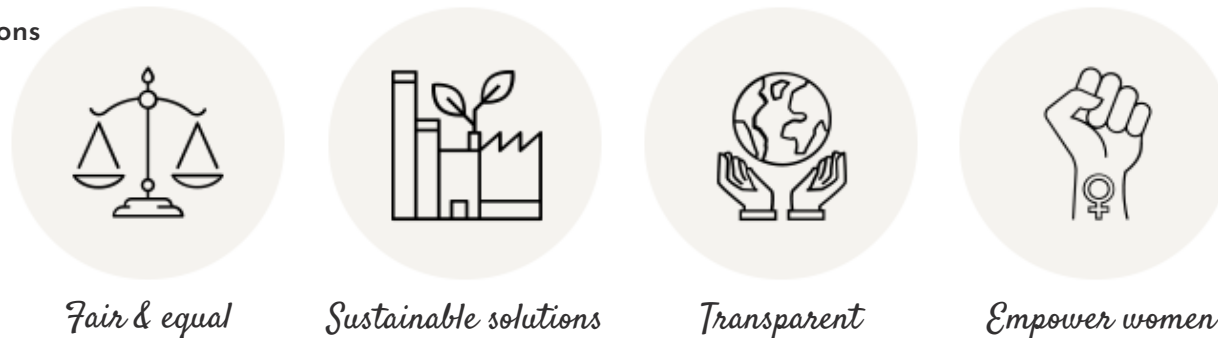
Most of MD's production processes take place in China. This projects aims to improve sustainability within these processes. Therefore, part of the research is executed in collaboration with suppliers in China.

2|2 Problem definition and scope

As mentioned, MD is aiming to work towards a sustainable business model. The fashion industry, MD included, has a complex supply chain and has little insight into the source of the materials of its products. Furthermore, there is a weak and indirect collaboration with the tier 2, 3 and 4 suppliers. Therefore, clarity on MD's supply chain and its environmental impact is lacking. Thus, the focus of the first phase of this project is on mapping and analysing the supply chain, the collaborations with stakeholders in the supply chain, and the environmental impact of the textile wet processes. Hereafter, solutions are generated to strengthen the collaboration with the selected suppliers. Finally, these solutions are presented in a collaboration strategy to improve production processes to decrease environmental impact in MD's supply chain.

During the project, there is a close collaboration with the product and development department of MD, located at the headquarters in Rotterdam. Also, there is a collaboration with tier 1 and tier 2 suppliers in China during the field research in November. Lastly, there is a collaboration with various industry experts to gain knowledge on textile wet processing and on supplier collaborations.

FIGURE 10. Key CSR ambitions
(MarliesDekkers, 2018)



2|3 Design challenge & research questions

Since this thesis ultimately develops and delivers a solution to a problem, a design challenge is defined. To structure the process from analyses to solution, five research questions are defined. Answering these research questions will support the process of solving the design challenge.

The design challenge that is answered in this thesis is defined as follows:

How can marlies/dekkers collaborate with suppliers in its supply chain to decrease the environmental impact of its textile wet processes?

The research questions are defined as follows:

- 1| How can sustainability be managed in a garment production supply chain?
- 2| How is the current collaboration between MD and its tier 1 and tier 2 suppliers?
- 3| How can the environmental impact of textile wet processes be decreased?
- 4| How can MD strengthen the collaboration with its suppliers?
- 5| How can MD implement the collaboration strengthening solutions?

2|4 Project setup

This project setup was written on the basis of the project brief, containing agreements made between the student, the supervisory team and MD about this graduation project (appendix 1).

Structure

To structure this project, the double diamond is used, as shown in figure 11 on page 29. This structure generally fits design processes, but can be stretched or morphed to fit a specific project (DesignCouncil, 2007). It consists of four phases, divided in two diamonds. In the first phase, discover, the project is diverging; a lot of knowledge is gathered and analyses are performed to generate a comprehensive overview of the problem. Then, in the second phase, define, the project is converged. All results from the discover phase are synthesised and converged to a set of design requirements, which will be the starting phase for the second diamond. In the third phase, develop, the project will diverge again, generating many possible solutions to the problem. In the final phase, deliver, all solutions generated in the develop phase will converge to a final deliverable. It is important to stress that this is a general structure for this project. Even though it is now presented as a fairly linear

process, it is in fact a more iterative process. Phases overlap and there are iteration loops within and between phases.

figure 11 also shows how and where in this thesis the research questions are answered. For example, the evidence and argumentation supporting research question three can be found in the analyses in chapters 6, 7 and 8. The first three research questions are answered in chapter "9 Synthesis & problem statement", the fourth research question is answered in chapter "11 Ideation & conceptualisation" and the fifth research question is answered in chapter "13 Roadmap & implementation plan".

Discover

The discover phase is seen as the most critical phase, because it highly influences the eventual outcomes of the project (DesignCouncil, 2007). It involves an extensive research of MD and its current production processes. Also, it includes a thorough industry analysis to define the sustainability in the fashion industry. Lastly, it involves a field research in China, visiting and interviewing suppliers.

Define

During the define phase, the scope of the develop phase is set. Analyses results are synthesised and the first three research questions are answered. Furthermore, interviews with industry experts fill knowledge gaps from the first phase. The results from these analyses are validated with MD employees. Finally, based on these results, design requirements for the final strategy are defined.

Develop

The develop phase is used to generate ideas to improve the production processes and collaboration strategies. A brainstorm with MD employees generates ideas that are used as an inspiration for the ideation phase, where a collaboration strategy is designed. Finally, a final concept is described.

Deliver

In the deliver phase, a roadmap to execute the collaboration strategy is delivered, along with an implementation plan. Also, final conclusions and recommendations are described.

2|5 Deliverables

The final deliverable of this project is defined as follows:

A collaboration strategy, that can lead to improved production processes to decrease the environmental impact of MD's supply chain.

Strategy is a word with many meanings and definitions. The most important ones are given:

- ◇ "The determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources for carrying out these goals" (Chandler, 1962);
- ◇ "The pattern of decisions in a company that determines and reveals its objectives, purposes or goals, produces the principal policies and plans for achieving those goals, and defines the range of businesses the company is to pursue, the kind of economic and human organization it is or intends to be, and the nature of the economic and non-economic contribution it intends to make to its shareholders, employees, customers, and communities." (Andrews, 1980);
- ◇ "A broad formula for how a business is going to compete, what its goals should be, and what policies will be needed to carry out those goals." (Porter, 1980) Later, Porter (1996, p. 62) defined strategic positioning as "performing different activities from rivals' or performing similar activities in different ways" (as opposed to operational effectiveness, defined as performing similar activities better than rivals perform them);
- ◇ "the framework which guides those choices that determine the nature and direction of an organization." (Tregoe & Zimmerman, 1981);
- ◇ "a pattern of purposes, policies, programs, actions, decisions, or resource allocations that define what an organization is, what it does, and why it does it." (Bryson, 1995);
- ◇ "A general plan of action for achieving one's goals and objectives" (Nickols, 2016, p. 3).

Looking at these different definitions of strategy, some aspects are present in (almost) all of them. To develop a collaboration strategy, a clear purpose should be defined, followed by objectives and then by tangible actions and decisions that must be taken to reach the defined purpose and objectives. An operational action plan is thus part of a strategy.

By developing a strategy instead of only an operational action plan, MD can better align the results of this thesis with its already existing (sustainability) strategy.

To create this final deliverable, three sub-deliverables are defined:

- ◇ Industry analysis & benchmark on sustainability in the lingerie industry. (chapter "3 Fashion industry & competitor analysis");
- ◇ Analysis of textile wet processes in the supply chain of marlies|dekkers. (chapter "5 Company & stakeholder analysis" and chapter "6 Textile wet process");
- ◇ Thorough analysis of current collaboration with stakeholders, especially tier 2 suppliers. (chapter "4 Overview of MD' supply chain", chapter "5 Company & stakeholder analysis" and chapter "7 Supplier research").

2|6 Relevance of this thesis

Relevance for Strategic Product Design

This thesis is relevant to the Strategic Product Design master programme in mainly two ways. The emphasis of the master programme is on translating a company's strategy and market opportunities into valuable product or service designs. This thesis contributes to this by translating MD's strategy and the opportunities in the fashion industry into a service design that is meaningful to all stakeholders.

Second, even though this research is mainly executed on the faculty of Industrial Design Engineering (IDE), there is some overlap with the faculty of Technology, Policy and Management (TPM). Thus, this thesis might contribute to more interfaculty research in the future, which could be valuable for both faculties.

Scientific relevance

Even though this thesis does not fill a research gap, the results might contribute to scientific research on sustainability in the textile industry or research on collaborating with suppliers. The results of this thesis may be useful to anyone conducting scientific research in the field of sustainability in the textile industry.

Societal relevance

In 2015, all United Nations member states signed the 2030 Agenda for Sustainable Development. As a part of this, the United Nations set up Sustainable Development Goals (SDG's). These are 17 goals that function as a blueprint to achieve a better and more sustainable future. The SDG's address global challenges the world is facing, including climate change and the environment. The goals are all interconnected and the ambition is to achieve all 17 by 2030.

Improving textile wet processes could lead to less water use, less water pollution and less greenhouse gas emissions. This way, this thesis could have a positive impact on the environment and contribute to several SDG's. All SDG's and the specific ones this thesis addresses are shown in figure 12. The specific impact MD and this thesis can have on the achievement of the SDG's is impossible to define and in all probability relatively small. Nevertheless, the SDG's can function as a framework to tell the story of sustainability improvements in an organisation and to consumers.



FIGURE 12. Contribution to SDG's

(H. Teeuwen, based on Media Ethics Lab, 2019; United Nations, 2019)

2|7 Conclusions

This chapter provided the setup of the project. The design challenge, research questions and deliverables were formulated and the relevance of this thesis was explained.

The design challenge is formulated as follows:

How can marlies/dekkers collaborate with suppliers in its supply chain to decrease the environmental impact of its textile wet processes?

This design challenge is solved with the support of five research questions, which are answered by conducting literature research, carrying out interviews with tier 2 suppliers and industry experts, conducting a survey, and organising brainstorm and input sessions with MD employees. The research questions are defined as follows:

- 1| How can sustainability be managed in a garment production supply chain?
- 2| How is the current collaboration between MD and its tier 1 and tier 2 suppliers?
- 3| How can the environmental impact of textile wet processes be decreased?
- 4| How can MD strengthen the collaboration with its suppliers?
- 5| How can MD implement the collaboration strengthening solutions?

This thesis focuses specifically on textile wet processing, including dyeing and printing of fabrics. These processes are mainly located at tier 2 suppliers in China.

During this research, there is a collaboration with MD employees, tier 2 suppliers in China and industry experts.

As a result, this thesis delivers a collaboration strategy, which aims to improved production processes to decrease the environmental impact of MD's supply chain.

This research is relevant to the Strategic Product Design master programme, because it is in line with the goal of the master programme. Also, it contributes to exploring possibilities of interfaculty research, since there is some overlap with the faculty of Technology, Policy and Management.

Furthermore, the results of this thesis may be useful to anyone conducting scientific research in the field of sustainability in the textile industry.

Lastly, this research, and the strategy, are in line with sustainability goals as stated in the UN Sustainable Development Goals. On a larger scale, improved environmental sustainability of the fashion industry could contribute to reaching the UN SDG's.



MD's products in the production line at a tier 1 supplier in China

PART II

Discover

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3

Fashion industry & competitor analysis

This chapter provides an overview of how sustainability is currently managed in the fashion industry. The first part describes an overview of industry coalitions, certifications and rankings that are used. The second part consists of a competitor analysis, describing and measuring sustainability strategies of MD's competitors. This chapter contributes to research question 1| "how can sustainability be managed in a supply chain?".



3|1 Industry marks

The fashion industry uses different industry marks to categorise companies, measure sustainability and inform consumers. This paragraph describes three groups of marks:

- ◊ Industry coalitions, where organisations are joined together to reach a common goal;
- ◊ Certifications and quality marks, used to inform consumers on an organisation's performance;
- ◊ Industry rankings, used to rank organisations on (environmental) performance.

The following paragraphs describe the most important industry marks used in the fashion industry.

Industry coalitions

There are various coalitions that companies in the fashion industry can join to work together towards more sustainable fashion brands. The most important ones in the industry are described here.

Modint

Modint is a Dutch business network for companies in the fashion and textile branch. Approximately 600 companies, including MD, joined this network. Modint aims to realise a valuable and sustainable future for the textile sector by focusing on sustainability, innovation and expertise (Modint, 2017).

Convenant Duurzame Kleding en Textiel

The "Convenant Duurzame Kleding en Textiel" (covenant of sustainable fashion and textile) is signed by approximately 70 organisations, including MD, that are committed to improve and control environmental and social sustainability in production countries (SER, n.d.). It is an initiative from the "Sociaal Economische Raad" (SER), an advisory council that advises the government on socially-economic topics. The council consists of 11 entrepreneurs, 11 employees and 11 independent experts.

Amfori

Amfori is a leading global business association for open and sustainable trade, bringing together over 2,400 retailers, importers, brands (including MD) and associations from more than 40 countries from all sectors (Amfori, 2015).

Sustainable Apparel Coalition

The Sustainable Apparel Coalition is a network of apparel, footwear, and textile companies that together aim to produce no unnecessary environmental harm and have a positive impact on the people and communities associated with its activities. They have 250 member organisations from 35 countries (Sustainable Apparel Coalition, n.d.-a).

ZDHC foundation

The Zero Discharge of Hazardous Chemicals (ZDHC) foundation oversees the implementation of the ZDHC Roadmap to Zero Programme. It is a collaboration of 30 brands, 103 value chain affiliates and 20 associates in the textile industry. The foundation drives the implementation of safer chemical management practices in apparel supply chains (ZDHC foundation, 2019). This means that this organisation focuses on environmental sustainability and specifically on chemical usage and wastewater management, both important aspects of the dyeing process.

Textile Exchange

Textile Exchange is a global non-profit organisation focusing on environmental sustainability in the textile value chain. They have approximately 400 members, including fashion brands, retailers, manufacturers, farmers and NGO's from 25 countries (Textile Exchange, 2018a).

Certifications and quality marks

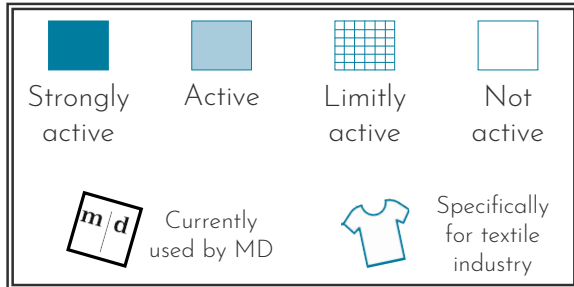
An overview of the most used certifications for environmental sustainability is given in figure 13 on page 38. This figure elaborates on 11 certifications, shows how actively they are used in different phases and which ones are currently used by MD.

Rankings

HIGG

The HIGG index is a set of tools, developed by the Sustainable Apparel Coalition to measure and score the sustainability of a product, company or brand. It measures both social and environmental sustainability in apparel supply chains. Even though 10.000 industry stakeholders are using the tool, it is not yet widely adopted, partly because the large amount of other sustainability measurement tools, partly because of the complexity of the tools and the high membership fee of the coalition (Sustainable Apparel Coalition, n.d.-b).

Legend



REACH



Raw materials	
Materials processing	
Garment finishing	

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) aims to improve the protection of human health and the environment through better and earlier identification of the of chemical substances in consumer products. All products sold in the EU must comply with REACH regulations (European Commission, 2019, August 7).

ISO14001



Raw materials	
Materials processing	
Garment finishing	

The International Organization for Standardization (ISO) is an independent, international non-governmental organisation that develops international standards and certifications for global challenges in all industries. ISO14001 is a certification that specifies requirements for environmental mangement systems (International Organisation for Standardization, 2015).

OCS100/OCS Blended



Raw materials	
Materials processing	
Garment finishing	

Organic Content Standard (OCS) is a certification developed by the Textile Exchange. It tracks certified organic material in textile value chains, from the farm to the final product. OCS100 applies to products that contain at least 95% organic materials, OCS Blended is for products with at least 5% organic materials (Textile Exchange, 2013).

Global Recycled Standard



Raw materials	
Materials processing	
Garment finishing	

The Global Recycled Standard (GRS) is a certification for products with recycled content, developed by the Textile Exchange. GRS strives to provide brands with a tool for more accurate labelling, to encourage innovation in the use of reclaimed materials, to establish more transparency in the supply chain, and to provide better information to consumers. (Textile Exchange, 2018b).

Nordic Swan Ecolabel



Raw materials	
Materials processing	
Garment finishing	

The Nordic Swan Ecolabel aims to reduce the environmental impact from production and consumption of goods in 60 different product groups. Currently, over 25.000 products have this ecolabel. It is mainly used in Scandinavia (Nordic Ecolabelling, n.d.).

FIGURE 13. Overview of certifications

(H. Teeuwen, based on ABN Amro, 2018; GoedeWaar.nl, 2012; Milieu Centraal, n.d.)

Bluesign

bluesign®
APPROVED

Raw materials	☐
Materials processing	☐
Garment finishing	☐

Bluesign is an independent organisation that strives to decrease environmental impact in the textile sector. It focuses specifically on chemicals and materials used by 600 companies who produce products that are bluesign certified (Bluesign, 2019).

EU Ecolabel

Raw materials	☐
Materials processing	☐
Garment finishing	☐

The EU ecolabel is an environmental quality mark for non food products and services to stimulate more sustainable consumption. It is recognised by all EU countries and many other countries worldwide (European Commission, 2019, October 25).

GOTS

Raw materials	☐
Materials processing	☐
Garment finishing	☐

The Global Organic Textile Standard (GOTS) is a processing standard for textiles made from organic fibres. It defines high-level environmental criteria along the entire organic textiles supply chain and requires compliance with social criteria as well. Only textile products that contain a minimum of 70% organic fibres can become GOTS certified (Global Standard gGmbH, 2016).

Cradle to cradle

Raw materials	☐
Materials processing	☐
Garment finishing	☐

Products can receive five levels of Cradle to Cradle certifications (Basic, Bronze, Silver, Gold, Platinum) in five different assessment categories (material health, material reutilisation, renewable energy, water stewardship and social fairness) (Cradle to Cradle Products Innovation Institute, 2019). Material health and water stewardship are particularly important in the dyeing process.

BEPI

amfori  **BEPI**
Trade with purpose



Raw materials	☐
Materials processing	☐
Garment finishing	☐

The Business Environmental Performance Initiative (BEPI) is a framework developed by Amfori to improve environmental performance in garment supply chains (Amfori, n.d.). MD is currently implementing this framework in its supply chain, however not yet any suppliers use it actively.

OEKO-TEX Standard 100

OEKO-TEX®
CONFIDENCE IN TEXTILES
STANDARD 100 



Raw materials	☐
Materials processing	☐
Garment finishing	☐

The OEKO-TEX Standard 100 is a testing and certification system for the textile industry. The standard is developed by 18 independent research institutes and focuses on reducing harmful substances to protect consumer health. Over 14,000 products from different factories are OEKO-TEX certified (OEKO-TEX, 2019). All MD's tier 1 and tier 2 suppliers are OEKO-TEX certified.

Good On You

Good On You is an independent ranking that ranks various fashion brands on social and environmental sustainability. The organisation uses information from over 50 industry certifications to determine whether a company is acting sustainably regarding people, planet and animals. To do so, the company uses an overall 5-point scale: | we avoid | not good enough | it's a start | good | great |. (Good On You, 2019).

Fashion Transparency Index

The fashion transparency index is an index that measures how transparent companies are about their social and environmental sustainability. This is measured yearly via a questionnaire filled out by 200 brands and retailers (Fashion Revolution, 2019).

Findings on industry marks

There are many different industry coalitions, certifications and rankings. This paragraph provided an overview of the most used ones.

The discussed industry marks are summarised in figure 16 on page 42. Also, the connections between these coalitions, certifications and rankings are visualised in figure 16. Many coalitions are members, contributors or supporters of other coalitions. Besides, many coalitions develop certain rankings or certifications.

It can be concluded that the industry is very complex and it is hard for both consumers and companies to decide which certifications and coalitions are valuable. Not all certifications can easily be obtained by all companies, some certifications require a membership of a specific coalition. Also, because there are so many different certifications that the added value for consumers is questionable. MD is not affiliated with many certifications, but this does not necessarily have to be problematic.

3|2 Competitor analysis

Main competitors

MD's main competitors in the lingerie branch are shown in figure 14, segmented on price. As shown, MD's products are in the upper middle price range (€€€€) and the high price range (€€€€€).

Table 1 on page 45 shows an overview of the sustainability performance of all mentioned competitors. Four aspects are taken into account. It is

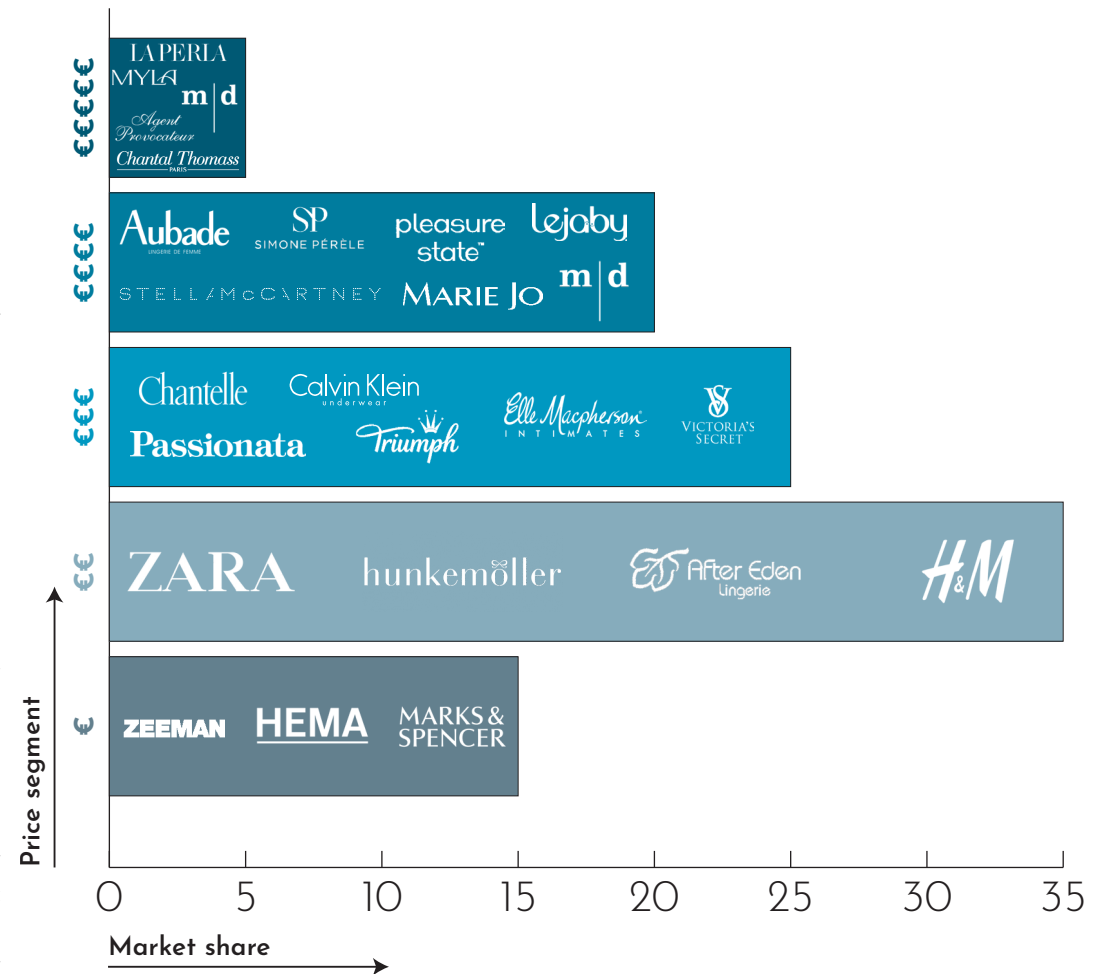


FIGURE 14. Competitors

(H. Teeuwen, based on internal communication)

measured to what extent companies are transparent about its (tier 1 and tier 2) suppliers. Furthermore, the transparency on social and environmental sustainability is scored on a 5-point scale. Lastly, the accuracy of reporting is described in the table. These aspects combined generate a final score on sustainability performance, as visualised in figure 15. This score is calculated by averaging the scores for supplier transparency, social sustainability and environmental sustainability.



FIGURE 15. Competitor scoring

(H. Teeuwen)

segments score better on sustainability transparency. However, many of these companies are producing other fashion products too and are significantly bigger companies than MD.

In its price range, MD scores relatively well on sustainability transparency, compared to direct competitors.

Industry examples

A more in-depth benchmark was set to analyse sustainability strategies of well-performing companies in the textile industry. Companies that are taken into account are:

- ◊ Chantelle Group (owner of Chantal Thomass, Chantelle and Passionata);
- ◊ Stella McCartney;
- ◊ Zara;
- ◊ H&M Group;
- ◊ Hunkemöller;
- ◊ Marks&Spencer;
- ◊ Zeeman;
- ◊ Hema;
- ◊ Adidas;
- ◊ Patagonia.

The information used to score these competitors on sustainability transparency was retrieved from websites and sustainability reports. Afterwards, the Fashion Transparency Index was used to validate the results.

(Although only four competitors are mentioned in the Fashion Transparency Index - Triumph, Zara, H&M and Marks&Spencer - the results from this report correspond to the results in table 1 (Fashion Revolution, 2019))

From table 1, it can be concluded that competitors in lower price

These are the best performing competitors of MD, complemented with two other fashion companies, Adidas and Patagonia, that scored best in the Fashion Transparency Index (Fashion Revolution, 2019). The highlights from each sustainability strategy are described in appendix 2. The most important findings are described in the next paragraph.

Findings on competitors

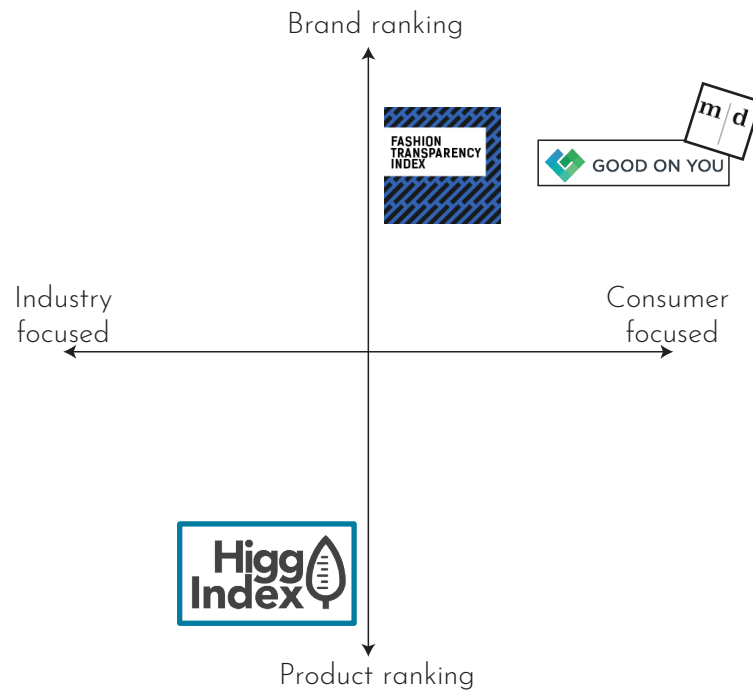
There is no doubt that transparency in the supply chain is important to achieve sustainability. Most competitors have disclosed supplier information, though some more detailed than others. The best examples are the interactive maps that H&M, Marks&Spencer, Zeeman, Hema and Patagonia published. However, some organisations only disclose basic supplier information, such as countries the suppliers are located. MD does well on sustainability transparency with the disclosure of a list of all tier 1 and tier 2 suppliers.

Most organisations that are doing well on sustainability issues collaborate with various global organisations to improve sustainability. Often, these organisations are shared on the websites of these companies. MD has not yet set up many collaborations with other organisations, but it might be valuable to set up collaborations with organisations to accelerate sustainability improvements.

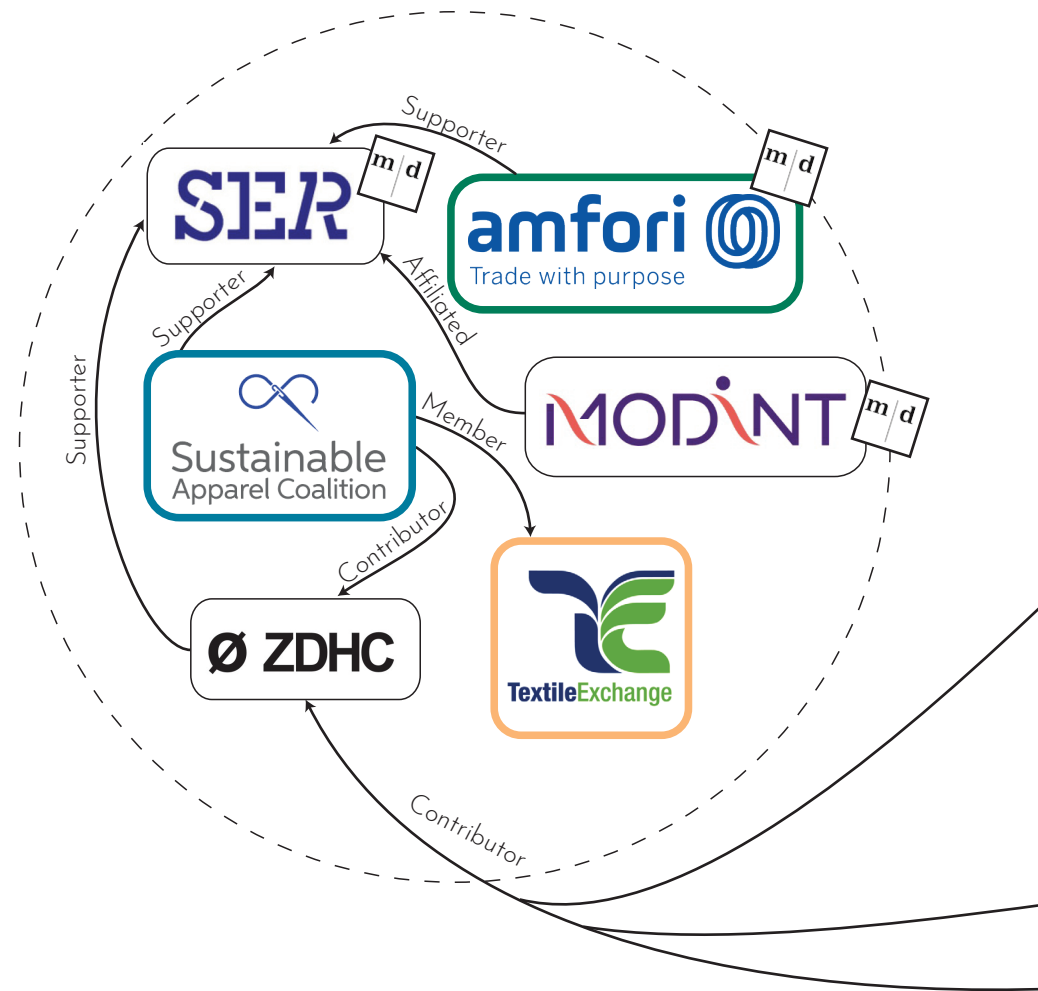
Some successful companies have set up collaborations with and between tier 1 and tier 2 suppliers. This might include the facilitation of platforms or networks where suppliers can share best case practices regarding sustainability. MD currently does not have such collaborations, though it could be interesting or even necessary to set up closer collaborations with tier 2 suppliers to improve the fabric dyeing process.

MD is currently ranked “not good enough” on the Good on You ranking. However, this was last updated in September 2018 and is thus outdated.

Rankings



Industry coalitions



Legend

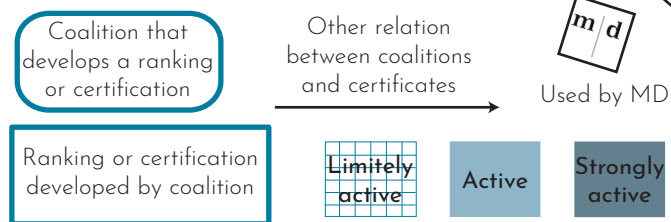
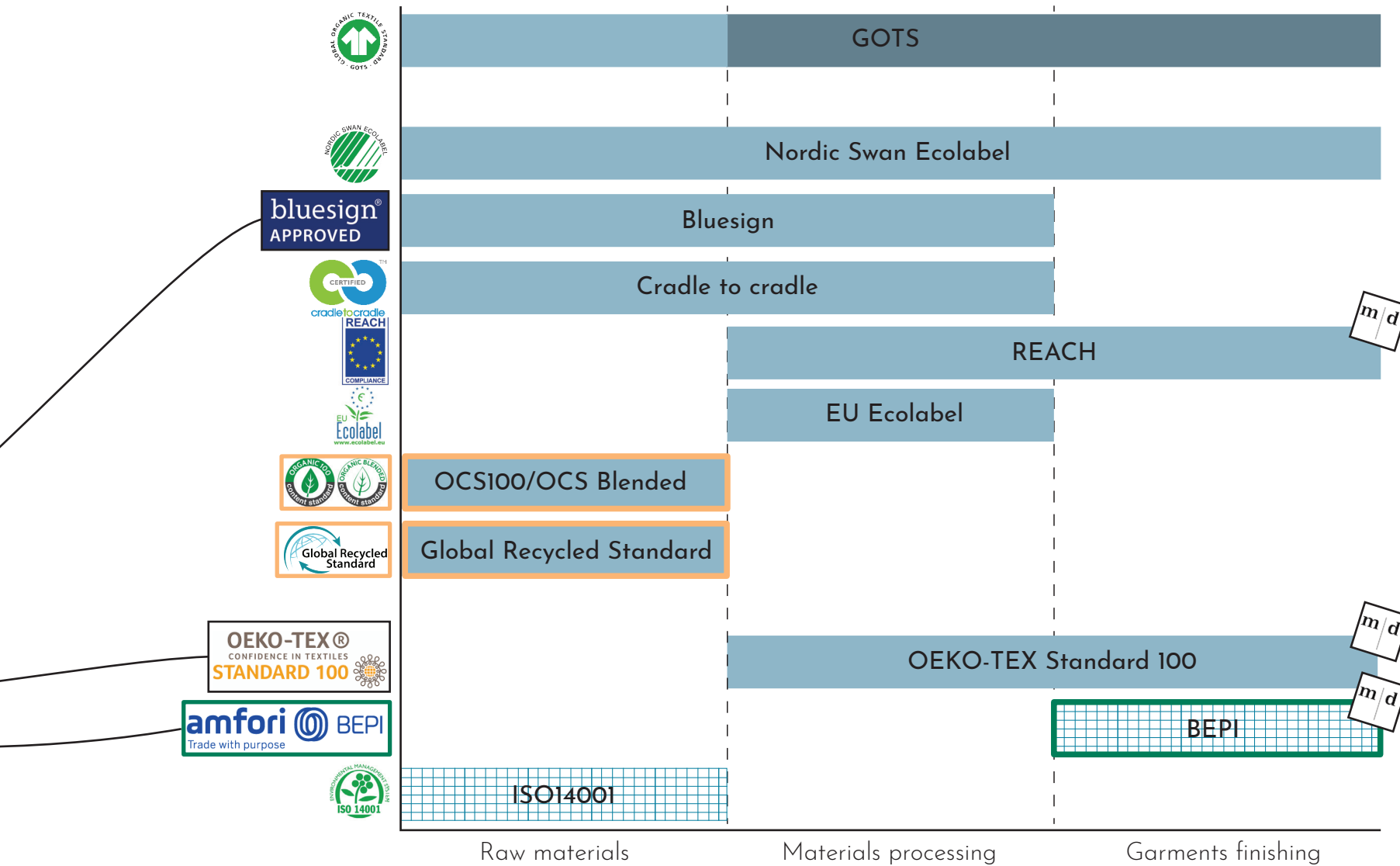


FIGURE 16. Overview industry coalitions, certifications and rankings

(H. Teeuwen, based on ABN Amro, 2018; GoedeWaar.nl, 2012; Milieu Centraal, n.d.)

Certifications and quality marks



		 Suppliers	 Social	 Environment	 Reporting	Overall *
€€€€	Myla				No reporting on sustainability issues.	
	La Perla				No reporting on sustainability issues.	
	Agent Provocateur				Published a statement on ethical trading and sourcing. Mentions supplier transparency and environmental sustainability, shares some details on social sustainability.	
	Chantal Thomass (Chantelle Group)				The holding company, Chantelle Group, shares detailed reports on environmental and social sustainability. Countries where suppliers are located are shared as well.	
	marlies dekkers				Detailed information on all tier 1 and tier 2 suppliers. Measurable social sustainability goals and results. Shares environmental goals, but little details on e.g. footprint.	
€€€€	Maison Lejaby				No reporting on sustainability issues.	
	Marie Jo				No reporting on sustainability issues.	
	Pleasure State				No reporting on sustainability issues.	
	Aubade (Calida group)				The holding company, Calida group, mentions sustainability as a priority but no details are shared.	
	Simone Pérele				No reporting on sustainability issues.	
	Stella McCartney				Very detailed on environmental sustainability, however this has not been updated since 2016. Detailed social sustainability strategy. No supplier information is shared.	
€€€	Chantelle (Chantelle Group)				The holding company, Chantelle Group, shares detailed reports on environmental and social sustainability. Countries where suppliers are located are shared as well.	
	Passionata (Chantelle Group)				The holding company, Chantelle Group, shares detailed reports on environmental and social sustainability. Countries where suppliers are located are shared as well.	
	Triumph				Mentions sustainability in its code of conduct and business ethics guidelines. Shares methods to measure social sustainability (BSCI), but does not share suppliers.	

		 Suppliers	 Social	 Environment	 Reporting		Overall *
	Calvin Klein (PVH)				The holding company, PVH, publishes a yearly CSR report on with detailed information. Supplier transparency is mentioned, but no details are shared.		
	Victoria's Secret (Lbrands)				The holding company, Lbrands, shares detailed information on social and environmental sustainability, however it is not shared who the suppliers are.		
	Elle Macpherson				No reporting on sustainability issues.		
€	Zara (Inditex group)				The holding company, Inditex group, shares detailed reports on sustainability. Supplier locations are shared, but no detailed information is shared.		
	Hunkemöller				Publishes a yearly report on social and environmental sustainability, but measurable results are lacking. Only the countries where suppliers are located are shared.		
	After Eden (Body Cover Group)				The holding company, Body Cover Group, mentions environmental and social sustainability (OEKO-TEX, BSCI) on its website, but no details are shared.		
	H&M				Shares a detailed supplier map on all tier 1 and tier 2 suppliers. Publishes a yearly CSR report with detailed information on environmental and social sustainability.		
€	Marks&Spencer				Shares a detailed supplier map on all tier 1 and tier 2 suppliers. Publishes a yearly CSR report with detailed information on environmental and social sustainability.		
	Hema				Shares a detailed supplier map on all tier 1 and tier 2 suppliers. Publishes a yearly CSR report with detailed information on environmental and social sustainability.		
	Zeeman				Shares a detailed supplier map on all tier 1 and tier 2 suppliers. Publishes a yearly CSR report with detailed information on environmental and social sustainability.		

Legend

-  0. Not mentioned
-  1. Mentioned, but no details shared
-  2. Some details shared
-  3. Details shared, but no measures or up-to-date results are shared (or details are not complete)
-  4. Details shared, including measureable goals and up-to-date results

* overall score was calculated by rounding the average of the supplier, social and environment scores

TABLE 1. Sustainability performance of competitors

(Agent Provocateur, 2020; Body Cover Group, 2017; Calida Group, 2019; CL, 2018; HEMA, 2019; H&M Group, 2019; Hunkemöller, 2019; Fashion Revolution, 2019; Inditex Group, 2019; LBrands, 2016; PVH, 2019; Marks&Spencer, 2019; Marlies]Dekkers, 2018; Stella McCartney, 2019; Triumph International, n.d.; Zeeman, 2019)

3|3 Conclusions

This chapter provided an industry analysis from two perspectives; industry marks and competitors.

Measuring sustainability in the fashion industry is very complex. There are multiple coalitions, certifications and rankings that are used to measure companies, brands and products on sustainability performances. Three notes on these industry marks can be given.

First of all, not all industry marks are equally used or equally easy to use. Some certifications require coalition memberships and some industry marks are more expensive than others. This hampers determining the possible value of an industry mark.

Secondly, all marks have different goals. Some certifications are meant to inform customers, while others are mainly used by companies to manage their own performances. Also, some coalitions are networks of organisations, collaborating to achieve a certain goal, while others are more an expression of committing to a goal individually. Having different goals also leads to different measurement methods, making it hard to compare organisations on sustainability performances.

Lastly, not all marks are as relevant to all organisations or at all times. For example, some certifications need to be obtained every year, and hence they are quite up to date, while others might be outdated.

Taking all this into account, the reliability and validity of industry marks varies. Because of the overall complexity of industry marks, the reliability and validity is in any way questionable. Depending on the organisation, however, the industry marks can be useful for

specific purposes. MD does not use many industry marks, but the ones currently used help the company execute its sustainability strategy.

Looking at competitors' sustainability performances, MD scores well in its price range. Some (larger) companies in lower price ranges are also scoring well on sustainability. It is undeniable that transparency in a supply chain is important to achieve sustainability, as competitors that are more transparent are often perceived as more sustainable. Many well-performing competitors collaborate with various organisations that help them execute their sustainability strategy. Also, many well-performing competitors have set up collaborations with suppliers to improve sustainability. Collaborations with suppliers and other organisations could be an opportunity to help improve sustainability in MD's supply chain, since it contributes to supply chain integration and alignment. However, MD is not comparable with these competitors, since it is a much smaller company. This should be taken into account when setting up a collaboration.

- 1 Context
- 2 Setup
- 3 Fashion industry & competitor analysis
- 4 Overview of MD' supply chain
- 5 Company & stakeholder analysis
- 6 Textile wet process
- 7 Supplier research
- 8 Industry expert interviews
- 9 Synthesis & problem statement
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- 11 Ideation & conceptualisation
- 12 Impact measurement
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4

Overview of MD' supply chain

The contents of this chapter are confidential and therefore only the conclusion is published. This chapter contributes to research question 2/ "How is the current collaboration between MD and its tier 1 and tier 2 suppliers?".



4|1 Conclusions

This chapter discussed the supply chain of MD, including different suppliers, product characteristics and cost.

MD's supply chain is complex and traceability and transparency in tier 3 and tier 4 are lacking. This is partly caused by the issues described in paragraph "1/4 Supply chain" and partly because of the complexity of the product. Lingerie consists of many different parts that require different production processes.

Textile wet processing, that this thesis focuses on, is, with exception of accessories, used in almost all product parts. The cost of textile wet processing only account for approximately 2,5% of the consumer price, while the environmental impact is probably much higher. This means that investing in sustainable textile wet processing could have a relatively high impact on the sustainability of MD's products, while having a relatively low impact on the price of MD's products.

91,2% of tier 1 and tier 2 suppliers is located in China (including Hong Kong). Of the Chinese suppliers, 72,5% is located in Guangdong, a province in the south. The fact that so many suppliers are located relatively close to each other, makes it easier for MD to manage supplier relations.

MD has outsourced part of its quality control to a local partner, locating in Hong Kong, providing some significant advantages for MD.

One advantage, and the main reason of outsourcing quality control to this local partner, is that it optimises the production

process. Because the local partner is located near the suppliers, in the same time zone, communication is easier and faster. Also, the local partner can check samples faster and the samples have to travel less distance to be checked. MD still has control over its production process and product quality because there is a close collaboration with the local partner.

5 Company & stakeholder analysis

The contents of this chapter are confidential and therefore only the conclusion is published. This chapter contributes to research question 2/ "How is the current collaboration between MD and its tier 1 and tier 2 suppliers?".

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5|1 Conclusions

This chapter provided an insight in the sustainability strategy of MD. Also, an extensive stakeholder analysis was executed.

MD is committed to improving sustainability in its supply chain. However, the production does not take place at MD, but at MD's tier 1 and tier 2 suppliers. To decrease environmental impacts in the supply chain, MD has to impact the activities of these suppliers.

MD currently uses five tier 1 suppliers (of which three are significantly more important). For textile wet processing in China, MD uses twenty different tier 2 suppliers, of which eight are nominated.

Regarding the relations with tier 1 suppliers, two remarks must be made. First, MD's orders account for 14% or less of the total turnover of tier 1 suppliers. This means that MD has little leverage at those suppliers. Despite the little leverage, MD has a good and close collaboration with tier 1 suppliers. A good example of this collaboration is the code of conduct. With the signing of this document, all tier 1 suppliers commit to, amongst other things, sourcing sustainable materials and receiving OEKO-TEX compliance.

When looking at the indirect relations with tier 2 suppliers, MD has less leverage than with tier 1 suppliers. However, there is a clear difference between regular suppliers and nominated suppliers. With the regular suppliers, there is a weak or non-existent relationship. This limits MD to impact these business.

With the nominated tier 2 suppliers, MD has regular contact and maintains a closer relationship. This provides opportunities for

collaborations to improve sustainability in the supply chain. Also, nominated suppliers are responsible for a relatively large part of MD's textile wet processing. All nominated tier 2 suppliers supply to at least 60% of the tier 1 suppliers.

The outcome of this project could increase the interest of some tier 2 suppliers in MD's businesses, increasing opportunities to impact them and improve sustainability.

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6 Textile wet process

This chapter describes the textile wet process. First, environmental impacts in the overall textile wet process are discussed. The second part of the chapter discusses environmental impacts in the various phases of textile wet processing, contributing to research question 3| “How can the environmental impact of textile wet processes be decreased?”.



6|1 Impact of textile wet processing

As mentioned in paragraph “1/3 Textile wet processes”, textile wet processing is the most significant stage in terms of environmental impact (Moazzem et al., 2018; World Bank, 2014). The textile wet process consists of multiple processes, shown in figure 17 on page 54. Because the environmental impact highly differs per material, textile mill and location, generalisable absolute impacts are hard to measure. In figure 17, general, average impacts are shown to give a simplistic overview of textile wet processes and its environmental impacts. It is important to stress that this process is much more modular than visualised. Not all processes are always needed or wanted. This is further elaborated upon in paragraph “6/2 Stages of textile wet processing”. Also, fabric production and drying are usually not included in the termination of textile wet processing, but because they also take place at tier 2 suppliers, fabric production and drying are taken into account in this overview.

Textile wet processes have a high environmental impact due to:

- ◊ Water pollution by chemicals and microfibers;
- ◊ Water use and the generation of large volumes of wastewater; and to a lesser extent:
- ◊ Energy, mainly to heat water and generate steam;
- ◊ Air pollution, due to emissions.

(Farrell, 2012; Gönlügür, 2019; World Bank, 2014)

Water pollution

The main source of water pollution in textile wet processing is the pollution of clean water by hazardous and toxic chemicals (Gönlügür, 2019; Kant, 2012). As an example, 20% of industrial water pollution globally is attributable to the dyeing and treatment of textiles (Kant, 2012). Various chemicals are used in every stage of the textile wet process, from pretreatment to washing. The wastewater is heavily polluted and often not treated well, due to the chemical complexity and high cost of wastewater treatment. Instead, it is often discarded in clean water sources, thus polluting even more water than the water that is actually used during textile wet processes (Gönlügür, 2019).

Besides water pollution through chemicals, the textile industry is a major contributor to the issue of plastic entering the ocean. During the process of dyeing and washing of plastic-based textiles, such as polyester or nylon, around half a million tonnes of plastic microfibers end up in the ocean every

year (Ellen MacArthur Foundation, 2017). It is estimated that 85% of human-made material released in the ocean are microfibers of materials used for clothing (O’Conner, 2014; Browne et al., 2011).

As shown in figure 17, pretreatment, dyeing, screen printing and finishing contribute most to water pollution.

Water use

Textile wet processing uses an intensive amount of fresh water and generates large volumes of wastewater (World Bank, 2014). For example, an average sized textile mill consumes approximately 200 liters of water per kilogram of produced textile. 16% of this is consumed in dyeing processes, 8% in printing processes (Kant, 2012), and the remaining 76% is used in other (textile wet) processes such as finishing, setting and washing. Looking at wastewater, for example, in Dhaka, Bangladesh, it was estimated that every day, 1.3 billion liters of heavily polluted industrial wastewater enters and pollutes the river system (World Bank, 2014). The dyeing process contributes to 15% - 20% of the total waste water flow of the textile industry (Kant, 2012).

Regarding water usage, an additional note should be made. There is a significant difference in water needs to dye different colours. To dye darker colours, more water is used during dyeing and washing processes. Also, some specific colours, such as turquoise and beige, are harder to realise and might need multiple attempts to get the colour right, thus generating more wastewater (OneWorld, 2017).

As shown in figure 17, dyeing and washing contribute most to water consumption and wastewater generation.

Energy use

To a lesser extent, energy use to heat water, generate steam and operate machines has an impact on the environment. In textile wet processing, a lot of energy is still generated by coal. However, some textile mills are shifting towards more sustainable energy sources such as gas or even renewable energy sources (Supplier interviews, personal communication, November 20-22, 2020).

In figure 17 it is shown that the processes of digital printing and setting uses the most energy.

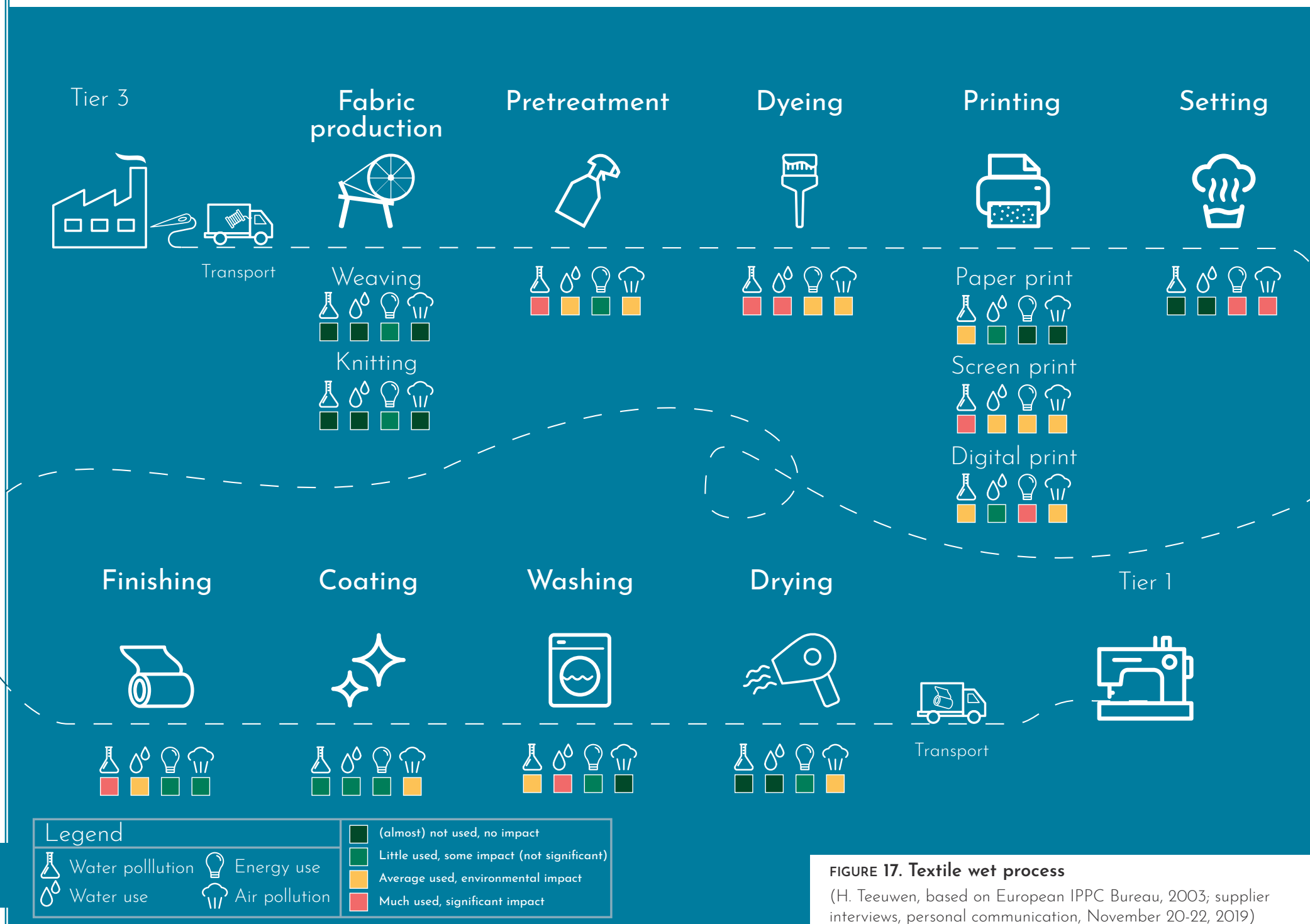


FIGURE 17. Textile wet process

(H. Teeuwen, based on European IPPC Bureau, 2003; supplier interviews, personal communication, November 20-22, 2019)

Air pollution

Air pollution during textile wet processing is mainly caused by the emission of greenhouse gasses that occurs when burning fossil fuels to heat water and generate steam (Raut et al., 2019). This happens mostly during the setting phase. Another cause of air pollution during textile wet processing is the release of hazardous chemicals in the air, mostly happening during the coating process (European IPPC Bureau, 2003).

6|2 Stages of textile wet processing

As mentioned, figure 17 on page 54 shows the different stages of textile wet processing. All stages are elaborated upon in this paragraph.

Fabric production

Even though fabric production is not part of textile wet processing, it is executed at the same mills and is therefore taken into account. The two different ways of fabric production that are most used are knitting and weaving.

Weaving

Weaving is only used for the more firm parts of a bra, such as wirecasing or shoulderstraps.

Knitting

Knitting is used to produce most fabrics used in lingerie. There are two types of knitting that are used; circular knitting and warp knitting.

Circular knitting is used to produce fabrics that feel a bit softer. Many small yarn bobbins are connected to a machine. The machine knits a circular piece of fabric and then immediately cuts the fabric to create a straight piece of fabric. A circular knitting machine is shown in figure 18.

Warp knitting is used to produce slightly tougher fabrics. To warp knit, the yarn needs to be transferred from the smaller bobbins to large bobbins, as shown in figure 19. After this happened, the large bobbins are used on the warp knitting machine (figure 20 on page 56) to produce fabric.

Pretreatment

The first stage in textile wet processing is the pretreatment phase. This phase is necessary for three reasons. First, the removal of foreign materials to improve uniformity, second, the improvement of the ability to absorb dyes



Above:

FIGURE 18. Circular knitting
(H. Teeuwen)

Below:

FIGURE 19. Bobbins
(H. Teeuwen)



FIGURE 20. Warp knitting
(H. Teeuwen)

uniformly and last, the relaxation of tensions in synthetic fibres (European IPPC Bureau, 2003). There are many different pretreatment methods that are used, depending on the material and desired outcome. One example that is often used is bleaching; before a yarn or fabric is dyed it is often bleached to ensure a homogeneous colour. Pretreatment can happen to the fabrics after they are knitted or woven, but it can also already happen to yarn. It is an intensive process that has a significant impact on the environment, especially regarding water pollution.

Dyeing



During the dyeing phase, colours are applied to the fabric or yarn. This means that dyeing can also happen before knitting or weaving. Before dyeing, the dyestuff needs to be prepared. This is done by entering colour recipes in a computer that then automatically mixes the chemicals in the right proportions, as shown in figure 21.

A distinction between three forms of dyeing is made; fabric dyeing, yarn dyeing and elastic dyeing. In fact, there are many different ways of dyeing fabrics, yarn and elastics as well, with different advantages and disadvantages.



FIGURE 21. Dyestuff preparation
(H. Teeuwen)

However, to keep this overview relevant and comprehensible a distinction was only made on the products that are dyed. All dyeing methods have similar impacts on the environment. A lot of chemicals are used that pollute the water, a lot of wastewater is generated, energy is used to heat water and through the burning of coal to generate energy, greenhouse gases are emitted, polluting the air. After a dyeing process, a setting process is always needed to adhere the dye to the fabric well enough to ensure a durable quality.

There are promising innovations in dyeing methods that use CO₂ to adhere dyestuff to fabrics, instead of water, but these methods are not yet used by MD's tier 2 suppliers. An employee of a company that develops this innovation is interviewed to gain more knowledge on using CO₂ to dye. The results are discussed in paragraph "8/3 Results".

Fabric dyeing

Fabric dyeing is used a lot, in many different ways. However, they mostly come down to the same thing; fabrics, dyestuff and auxiliaries are put together in large machines and with a combination of (hot) water and pressure, the

dyestuff adheres to the fabric. Different materials might need different machines, dyestuff or auxiliaries. An example of a fabric dyeing machine is shown in figure 22.

Yarn dyeing

Sometimes, yarn is dyed instead of fabrics. Yarn is needed to sew pieces of fabric to clothing, and often it is desirable that the yarn is dyed in the same colour as the fabrics used. A different, smaller machine is used, where undyed bobbins are put in and can be dyed as a whole. This machine is shown in figure 23.

A promising development in textile wet processing is “dope dyeing”. Instead of the conventional fabric dyeing, where yarn is knitted or woven into fabric before it is dyed, dope dye is the opposite. Yarn is first dyed in the desired colour and then knitted or woven into fabric. Dope dye has a lower environmental impact, but is not yet widely adapted. An employee of a tier 2 supplier that uses this innovation is interviewed to gain more knowledge on dope dyeing. The results are discussed in paragraph “8/3 Results”.

Elastic dyeing

The last dyed material that is discussed is the dyeing of elastics. Elastic fabrics often contain rubber and need a special method of dyeing. As shown in figure 24 on page 58, elastics can be dyed by guiding them through a “dye bath”. Another way of dyeing elastics is in an elastic dyeing machine, as shown in figure 25 on page 58.

Printing

Sometimes, fabrics have multiple colours and patterns, as in figure 26 on page 58. To achieve this, a printing process is needed where this pattern is printed on the fabric. A printing process can replace a dyeing process, however, often a fabric is first dyed in the background colour and then printed.

In general, printing has a lower impact on the environment than dyeing. There are three different ways to print fabrics, each with different advantages and disadvantages.

Paper print



With paper print, an image or pattern is printed on a special type of paper and then transferred on the fabric. A great advantage is that a setting process is not needed with paper print. This makes paper print the most sustainable option. Also, an unlimited amount of colours is possible. On the



Above:

FIGURE 22. Fabric dyeing machine
(H. Teeuwen)

Below:

FIGURE 23. Yarn dyeing
(H. Teeuwen)



Above

FIGURE 24. Elastic dyeing bath

(H. Teeuwen)

Below:

FIGURE 25. Elastic dyeing machine

(H. Teeuwen)

**FIGURE 26. Printed fabrics**

(H. Teeuwen)

other hand, paper print often generates a poor quality; after a few washes the print often cracks.

Screen print



With screen printing, large stencils, called screens, are used to put dyestuff on parts of a fabric. To generate a certain print on the fabric, multiple layers of colours are printed over each other, using different screens, as shown in figure 27 on page 59. The advantage of this method is that the dyestuff is printed into the fabric instead of on the fabric. This gives screen printed fabrics a better quality. On the other hand, this means that screen printing is the least sustainable printing method, because it uses most water and chemicals. Also, it always needs a setting process. Lastly, a limited number of colours can be used, depending on the amount of screens that fit on the length of the machine.

Digital print



With digital printing, a large printer is used to print on a piece of fabric. Very detailed patterns and unlimited amounts of colours are possible, which is a great advantage. Also, it uses and pollutes less water than screen printing, but does also need a setting process. Digital printing is twice as expensive as

screen printing (Supplier interviews, personal communication, November 20, 2019) and therefore less used. Also, the quality of the print is lower, because the pattern is printed on a fabric. When a fabric would be stretched, the unprinted (often white) parts of the fabric are revealed. A digital printer is shown in figure 28.

Setting



All dyeing processes and some printing processes need a setting process to ensure durable quality of the colours. During the setting process, the fabric is pressurised with hot steam, around 200 degrees Celsius to adhere the dyestuff to the fabrics. This process is impacting the environment by using energy and emitting greenhouse gasses (to a great extent devoted to energy sourcing, often by burning fossil fuels).

Finishing



After dyeing and/or printing fabrics, a finishing process is often needed to improve the look, performances or feel of the fabric, because a dyeing process makes a fabric more rough. This can happen in many ways, depending on the desired result. These finishing processes use large amounts of chemicals and water.

Coating



Sometimes, a coating or lamination is needed to produce a certain type of fabric. For example to make a fabric water resistant or give it a leather look and feel. Different coating processes exist, and they can be executed in many ways, using chemicals. The exposure of chemicals often causes air pollution.

Washing



Before the fabric is ready to use, it is washed to ensure that no hazardous chemicals remain in the fabric. This process increases water consumption and water pollution.

Drying



After the fabric is washed, it is dried, often using heat and/or steam. This has a small impact on the environment on air pollution and energy use.



Above:

FIGURE 27. Screen printing
(H. Teeuwen)

Below:

FIGURE 28. Digital printing
(H. Teeuwen)

6|3 Conclusions

This chapter provided insights in environmental impacts of textile wet processing.

Textile wet processing consists of multiple processes, including pretreatment, dyeing, printing, setting, finishing, coating and washing. The order in which processes are executed can vary according to the desired results, and not all processes are always needed.

Textile wet processing has a high impact on the environment. Textile wet processing uses a significant amount of fresh water and generates a lot of polluted wastewater, that is often discarded in clean water sources. This way, the process pollutes even more water than it uses. Water pollution in textile wet processing is mainly caused by the release of chemicals and microfibers in the water. Energy usage and air pollution, often caused by burning fossil fuels to generate energy, are other negative impacts on the environment, although they are less significant than the water related issues.

It can be concluded that dyeing and printing processes contribute a lot to the harmful impact of textile wet processing. There are some sustainable developments in textile wet processing that could provide solutions to the aforementioned environmental issues. For example, dyeing methods that use CO₂ to adhere the dyestuff to the fabric are a promising development. Also, dope dyeing, where yarn is dyed before it is woven or knitted as opposed to dyeing knitted or woven fabrics, could possibly decrease environmental impacts significantly.

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7 Supplier research

This chapter describes the supplier research that was partly executed in China. First, the set up and goal of the supplier visits and the survey are explained, after which the results are presented. Lastly, the reliability and validity of the results are evaluated. These results contribute to research question 2| “How is the current collaboration between MD and its tier 1 and tier 2 suppliers?” and 3| “How can the environmental impact of textile wet processes be decreased?”.



The supplier research consisted of two parts; factory visits to four tier 2 suppliers and one tier 1 supplier and a survey sent to all other dyehouses that are MD suppliers. The results were sent to all participants to validate them.

7|1 Supplier visits

Goal

The goal of the supplier visits is twofold. The first goal is to deepen knowledge on textile wet processing and its environmental impact by gathering quantitative data on energy usage, water usage, water pollution and chemical management. Second, the goal is to get an idea of general sustainability management in Chinese garment factories as well as suppliers' strategies regarding sustainability and willingness to collaborate with customers and other suppliers.

Suppliers

One tier 1 supplier was visited in the south of China.

The tier 2 suppliers to visit were selected by MD and the tier 1 supplier. The tier 2 suppliers were mainly selected on location and diversity. Suppliers of different sizes and different fabric productions were selected for this research to ensure a broad perspective.

All suppliers visited were located in the province of Guangdong, in the south of China.

The following suppliers were visited:

- ◊ Tier 1 supplier, factory visit;
- ◊ Tier 2 supplier A, factory visit and interview;
- ◊ Tier 2 supplier B, factory visit and interview;
- ◊ Tier 2 supplier C, factory visit;
- ◊ Tier 2 supplier D, presentation, an office was visited instead of the factory.

Questionnaire

Before the visit to China, a questionnaire was sent to the tier 2 suppliers (appendix 3). During the visit, the completed questionnaire was used as a starting point for a semi-structured interview (appendix 4).

Interviews

Semi-structured interviews were used to stimulate a discussion on sustainable production between MD and the tier 2 suppliers.

The visit to the tier 1 supplier did not include an interview, because it is a tier 1 supplier that does not have in-house textile wet processing. This visit consisted only of a factory visit to understand the production process of lingerie. One employee of the tier 1 supplier joined all visits to tier 2 suppliers to support and partly translate the interviews.

The visit to tier 2 supplier A consisted of a factory visit and an interview. During the interview, four employees were present. The interview lasted approximately 30 minutes.

The visit to tier 2 supplier B also consisted of a factory visit and an interview. During the interview, three employees were present. The interview lasted approximately 40 minutes.

The interviews with employees from tier 2 supplier A and B are recorded and transcribed (appendix 5) to obtain useful information, discussed under "7|3 Results".

The visit to tier 2 supplier D did not include a factory visit, because the factory is not located in Guangdong. Instead, an office was visited. Also, this visit included a presentation instead of an interview, due to limited time and because tier 2 supplier D had filled in the questionnaire thoroughly and presented it clearly.

Tier 2 supplier C did not prepare our visit, so employees responsible for sustainability were not present. The employees that we did meet filled in the questionnaire, however they were not able to provide a lot of information. During the visit, they mentioned that they would contact the responsible employees and send a completed questionnaire later.

7|2 Survey

Goal

The goal of the survey was to obtain more knowledge and data on textile wet processing. During the factory visits, only four factories could be visited due to the limited time and widespread locations of tier 2 factories. Therefore, a survey was sent to all tier 2 suppliers that were not visited (appendix 6). A survey is useful for obtaining information from individuals (Peterson, 2000). The questions in the survey are comparable to the questions that were asked during supplier visits.

Suppliers

The survey was sent to 19 tier two suppliers in China, of which three suppliers indicated that it did not have textile wet processing and thus were unable to fill in the survey. First, the survey was sent via Google and completed by two suppliers. However, many others suppliers indicated that they were unable to open the form due to Chinese internet restrictions that do not allow Google. Therefore, the survey was also sent via Typeform.

Typeform indicated that the survey had 20 unique visits, including a few MD employees to test the survey, but only five responses. This probably means that many suppliers did open the survey but did not respond. The average time that the five respondents needed to fill in the survey was approximately one hour.

In total, seven suppliers completed the survey, two via Google and five via Typeform.

Response rate

Out of 16 approached suppliers, seven filled in the survey, giving a response rate of 43,75%. One supplier indicated that it could not disclose the information that was asked for in the survey, the other nine did not respond.

The tier 2 suppliers that responded and the tier 1 suppliers they supply to are indicated in table 2. Many tier 2 suppliers supply to multiple tier 1 suppliers.

	Tier 1 A	Tier 1 B	Tier 1 C	Tier 1 D	Tier 1 E
Tier 2 E	✓	✓			
Tier 2 F	✓		✓		
Tier 2 G	✓		✓		
Tier 2 H	✓	✓	✓		
Tier 2 I	✓	✓	✓	✓	
Tier 2 J	✓	✓	✓	✓	✓
Tier 2 K	✓	✓	✓	✓	✓

(Gray: non-nominated suppliers. Blue: nominated suppliers)

TABLE 2. Responses suppliers

(H. Teeuwen)

A few things can be concluded from this response rate.

First, the 43,75% response rate can have multiple causes:

- ◊ The survey was in English. Some suppliers might not have understood the questioning due to a language barrier;
- ◊ Quite detailed information on sustainability was asked. The average time to complete the survey, one hour, is high. It might have been that suppliers did not want to take the time to fill in the survey;
- ◊ Not all contact details are verified. Even though MD has email addresses of all suppliers, MD does not have regular contact with all of them. It might be the case that some contact details are outdated and some suppliers did not respond the survey. Also, the contact details MD has, are often from sales departments, that might not have access to the information that was asked;
- ◊ One supplier indicated that it was not able to disclose information that was asked for in the survey. Probably other suppliers did not want to share this data, but did not respond that via email.

Secondly, it is interesting to notice that 6 out of 7 suppliers that responded supply to Kin Wah. This could mean that Kin Wah specifically sources at suppliers that are more open about their sustainability strategies, but it could also be coincidental.

7|3 Results

This paragraph discusses the results of the supplier visits and the survey. These are the results of 11 suppliers, four who were visited and interviewed and seven who completed the survey. An extensive report of all results from the supplier research can be found in appendix 7.

Sustainability strategies

All suppliers are tackling sustainability issues in textile wet processing. Most suppliers have invested in a water treatment system, that is able to clean water after it is used for textile wet processing. Two suppliers mentioned that they are investing in renewable energy sources, such as solar panels, to decrease environmental impact. Some other suppliers are also planning to use gas instead of coal, which could be a more sustainable energy source. However, using gas as an energy source is still harmful to the environment.

Suppliers mentioned that the demand for sustainable materials is growing, especially from European customers. This seems to be a reason for suppliers to act more sustainably.

Insights in legislation

A few years ago, the Chinese government set up strict laws regarding environmental sustainability. For example, the government sets limits on the amount of water a factory can use and suppliers are thus forced to invest in water treatment plants to recycle and reuse water. Factories are regularly visited by the government, if suppliers do not meet government requirements regarding sustainability, they have to close their factory. Suppliers indicated that this legislation will be more critical in the future (appendix 5). On the one hand, this fact probably accelerates sustainability improvements. On the other hand, factories closing could threaten MD's business. Prices could increase and MD might lose suppliers.

Supplier collaboration

One supplier mentioned a collaboration with other suppliers:

"Actually, for some brands we will have the workshop. We will invite the different suppliers for tier 1 or tier 2 to sit together to share the experience or to discuss the future trends, how we work sustainable, and actually we share everything of our experience during the workshop."

The responses to the survey, the enthusiasm during supplier visits and this example indicates that suppliers are willing to share information on sustainability performances with other suppliers. Also, because of the increasing demand for fabrics and because of the strict Chinese legislation, suppliers mention that they are looking for opportunities to "make progress together". Also, the suppliers visited were quite proud of their sustainability progress and liked to share this with us.

Certifications used by suppliers

figure 29 shows the certifications that are used by MD's tier 2 suppliers. The OEKO-TEX certificate is used by all suppliers, confirming MD's statement that all tier 1 and tier 2 suppliers are OEKO-TEX certified.

This data reveals the following insights:

- ◇ The industry certifications mentioned in chapter "3 Fashion industry & competitor analysis" are not widely used amongst MD's suppliers. Only seven certifications are used, of which only three were used by more than half of the suppliers;
- ◇ Six suppliers (54,5%) indicate that they use the Global Recycled Standard, meaning that they can produce recycled fabrics. This could be an opportunity for MD to decrease environmental impact;
- ◇ Six suppliers (54,5%) indicate that they use the Higg index to measure

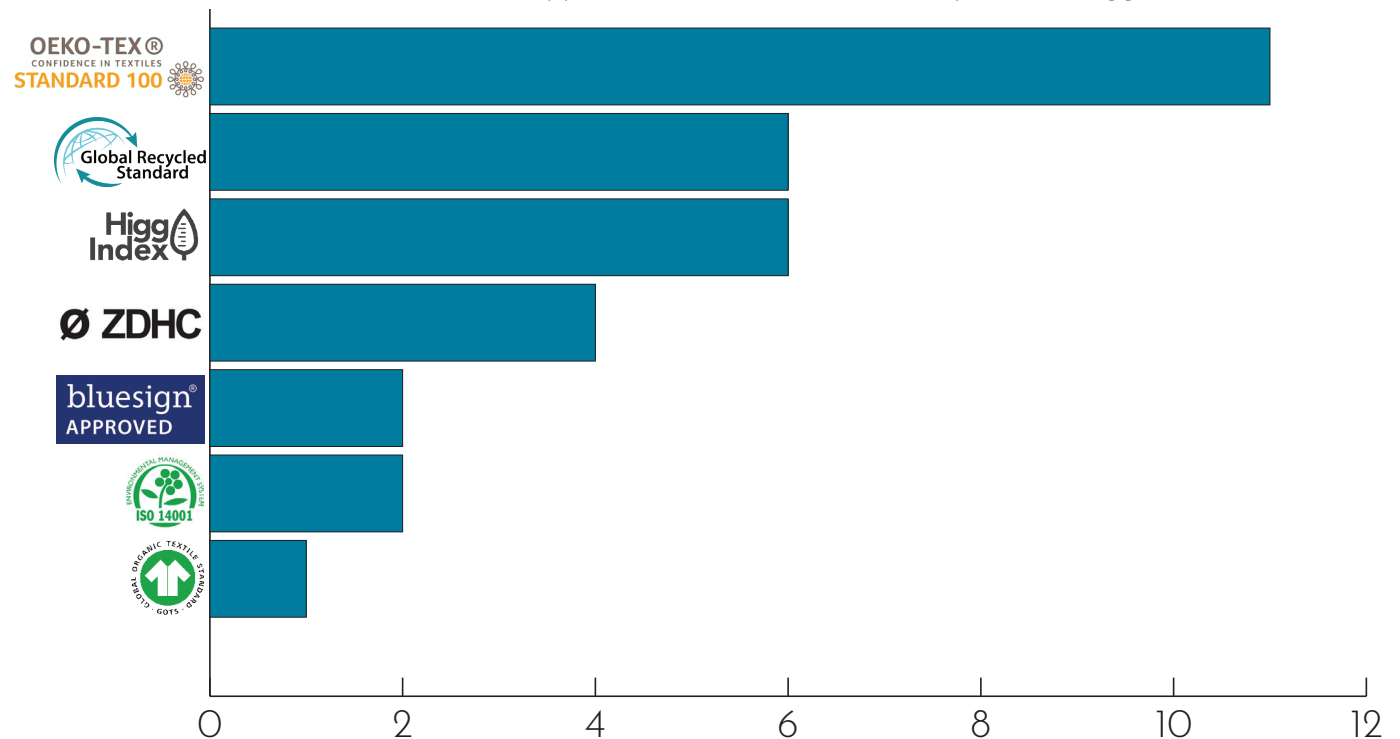


FIGURE 29. Certifications used by suppliers
(H. Teeuwen)

and manage environmental sustainability. The tools used with the Higg index are detailed, meaning that these suppliers have detailed information on their environmental impacts, such as water usage and water pollution.

Water consumption

All suppliers mention that they measure water consumption. However, the amount of water that is used to produce a ton of fabric, varies widely because of three main reasons. First, the material of the fabric significantly impacts the amount of water that is needed to dye it. Second, the desired colour of the fabric impacts the water needed. Darker colours usually need more water. Third, due to the complexity of textile wet processing as described in chapter “6 Textile wet process” it is hard to measure the exact amount of water used to produce a ton of fabric.

Wastewater management

Six suppliers indicated that the Chinese government sets limits on water usage for the factories. This means that recycling and reusing water is the only way to increase production capacity once the limits are reached. All 11 suppliers have their own water treatment system to clean water used in the textile wet processes. After treatment, part of the water is reused in the dyeing process, the rest is discarded into municipal water pipes or to professional water treatment companies for further treatment. Only one supplier mentions that it discards cleaned wastewater to the river.

The amount of water suppliers can treat and recycle varies widely. Suppliers indicate that they are able to recycle approximately 46% of their wastewater on average, however measure are between 6% and 95%. There might actually be such a big difference, but it is also possible that suppliers use different measures or did not fully understand the question.

Looking at the industry, it is stated that water treatment and recycling in a textile mill could reduce water consumption by 34% (Erdogan et al., 2004; Chougule & Sonaje, 2012). Furthermore, recycling of treated wastewater is found to be technically feasible and economically viable in the textile dying industries (Ranganathan, Karunakaran & Sharma, 2007). Treating and reusing wastewater is an opportunity to decrease the environmental impact of textile wet processing and so all suppliers set ambitions to increase water recycling in the coming years. A water treatment system is shown in figure 30.

Energy consumption

All suppliers mention that they measure energy consumption. However, as with water consumption, the amount of energy used varies widely.

Regarding energy sources, all suppliers use gas or coal to generate steam. Also, electricity is used a lot, mainly for digital printing. Two suppliers indicate that they make use of renewable energy sources, such as solar panels, another supplier mentioned that renewable energy is not yet used in textile mills (appendix 5).

Chemical management

10 out of 11 suppliers indicate that they measure the amount of chemicals used in their textile wet processing, however, as with water and energy consumption the amount of chemicals used varies too much to draw any conclusions. Chemicals that are used are mostly dyes and auxiliaries. All suppliers use a restricted substances list (RSL). An RSL is a list of hazardous chemicals that cannot be present in consumer products, to ensure consumer safety. All products sold in the EU must comply with REACH regulations, which is an example of an RSL.

A more profound RSL is a manufacturing restricted substances list, an MRSL. This is a list of hazardous chemicals that should be avoided throughout the entire manufacturing process, thus also taking employee safety into account. In the fashion industry, for example ZDHC has developed an MRSL. In all probability, nine suppliers use an MRSL.



FIGURE 30. Water treatment
(H. Teeuwen)

7|4 Reliability and validity

Validity and reliability of research are important elements to provide evidence of the quality of research (Hayashi, Abib & Hoppen, 2019). To be able to judge and use the results of this research, reliability and validity are tested.

A distinction between different results must be made, because reliability and validity cannot be defined in the same way for qualitative and quantitative research (Golafshani, 2003). The paragraphs about “Sustainability strategies”, “Insights in legislation” and “Supplier collaboration” discuss qualitative results whereas the paragraphs about “Certifications used by suppliers”, “Water consumption”, “Wastewater management”, “Energy consumption” and “Chemical management” describe quantitative data. For both the qualitative and the quantitative results, reliability and validity are discussed.

Reliability

Reliability is whether an instrument can be interpreted consistently across different situations (Bryman, 2012, p. 46). In quantitative results, this definition is sufficient; to what extent would this research generate comparable results if it were executed at another time? However, in qualitative research, this definition is not suitable, instead, reliability is used as a metric of the quality of the study; to what extent do the results contribute to understanding a situation that would otherwise be enigmatic or confusing (Eisner, 1991).

Reliability of qualitative results

When looking at qualitative results, the reliability is quite high. The semi-structured interviews and factory visits helped to gain a better understanding of textile wet processing, sustainability practices in Chinese garment factories and possibilities of supplier collaborations.

Reliability of quantitative results

Looking at the quantitative results, reliability is lower. As mentioned, suppliers use different measures to measure resource consumption and are not consistent in reporting this. Also, a lot of suppliers do not measure all resource consumption. This harms the reliability of the study.

Validity

Validity is whether an instrument actually measures what it sets out to measure (Bryman, 2012, p. 47). Again, this definition is sufficient for quantitative data, as this is measurable data. For qualitative data however, another definition

is brought forward. Ravitch & Mittenfeller (2015, p.186) define validity in qualitative research as “ways that researchers can affirm that their findings are faithful to participants’ experiences”.

Validity of qualitative results

Looking at qualitative results, validity is quite high. The semi-structured interviews and factory visits contributed to validity because they were held in China. This way, participants were able to show their production, increasing validity of the research. Also, as mentioned, the results were validated by the suppliers by email.

One remark must be made. Because of the language barrier, some interviews were translated which might have hampered the validity of the research.

Validity of quantitative results

The validity of the quantitative results is lower. Because there are no clearly defined measures to measure environmental sustainability, suppliers all measure different things in different ways. Even when suppliers use the same metrics to measure certain values, results vary widely, questioning the validity of the results.

7|5 Conclusions

This chapter discussed the supplier research that was executed, partly in China.

Most suppliers are investing in sustainable developments, however the incentive to do so, is either strict Chinese regulations, demand from (large) customers, or both. The Chinese regulation is expected to become more strict in the coming years, which might help increase sustainability improvements at tier 2 suppliers. However, a downside to stricter regulation could be that factories have to close, increasing prices due to a lower supply and causing problems for MD if its own suppliers have to close. Furthermore, suppliers are looking for ways to learn from each other and exchange knowledge. Some tier 2 suppliers already set up collaborations with tier 1 suppliers and/or brands to improve sustainability together.

All questioned suppliers have their own water treatment system to clean water after textile wet processing. All suppliers measure water consumption and energy consumption, 10 suppliers (of 11 respondents) measure chemical consumption. However, the metrics used differ per supplier and the results vary widely. The reliability and validity of the quantitative results is questionable.

Nevertheless, this research has provided useful qualitative results on sustainability strategies, legislations and supplier collaborations.

PART III

Define

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8 Industry expert interviews

To deepen the knowledge on the context of this thesis, four experts were interviewed. This chapter describes the goal, setup and results of these interviews. The expert interviews contribute to research question 3| "How can the environmental impact of textile wet processes be decreased?" and 4| "How can MD strengthen the collaboration with its suppliers?".



8|1 Goal

The goal of the expert interviews is threefold. First, the industry experts provide deeper knowledge on the context from various perspectives. They are able to fill knowledge gaps that emerged in the discover phase. Second, expert interviews contribute to answering research question 3 and 4. Lastly, the industry experts provide input in the design requirements, defined in chapter “10 Design requirements”.

8|2 Method

Semi-structured interviews

The four expert interviews are executed as semi-structured interviews. With this method of interviewing, there is an interview guide with a list of questions and specific topics to cover, but the structure of the interview is not yet completely defined. This provides flexibility to the interviewee to answer in his or her desired manner and it provides flexibility to the interviewer to follow up on questions (Bryman, 2012). This is similar to the general interview guide approach (Patton, 2002). The main advantage of this interview guide approach in this case is that the interviewer can make optimum use of the limited time available while still being able to spontaneously build a conversation within a particular subject area. Since all industry experts have a different area of expertise, four different interview guides are set up (appendix 8). After the interviews, the results were sent to the participants to validate them and deliver more input were needed.

Participants

Four different industry experts are interviewed:

- ◊ **Solidaridad.** Solidaridad is a civil society organisation that initiates and guides sustainability projects worldwide. In 2013, the organisation started the Better Mill Initiative in China, targeting 75 textile mills in China. The Better Mill Initiative offers trainings, network meetings and technical support to mills in regard to sustainable textile dyeing processes. One Solidaridad employee is interviewed on setting up a collaboration with and between suppliers and on creating support among tier 2 suppliers. The interview was held at the office of Solidaridad in Utrecht and took approximately 40 minutes;
- ◊ **CO2 dyeing company.** This company develops a way of textile dyeing, using CO2 instead of water. One employee is interviewed on the

development of this technology, how it can be implemented in factories and how and when this technology could become widely available. The interview was held at the office of this company, lasted approximately half an hour and included a factory tour;

- ◊ **Tier 2 supplier.** A tier 2 suppliers that uses dope dyeing is interviewed. One employee is interviewed on the environmental benefits of dope dyeing and how to implement this. The interview was held via skype and took 20 minutes;
- ◊ **Tier 3 supplier.** A chemical tier 3 supplier, supplying dyestuff to several tier 2 suppliers in China is interviewed. One employee is interviewed on sustainable solutions in conventional methods of dyeing and on the developments in (Chinese) regulations. The interview is held via skype and lasted an hour.

8|3 Results

This paragraph discusses the most important insights and takeaways from the expert interviews.

Solidaridad

The Better Mill Initiative that Solidaridad started in 2013 is a good example of a close collaboration with suppliers. The focus of this programme was reducing the environmental impact of wet processing facilities by working on water, energy, chemical and waste water issues. Also, there was a focus on pollution prevention, safety of employees and more sustainable resource consumption. To commit suppliers to the Better Mill Initiative, the employee mentions five success factors:

- ◊ **Brand engagement.** Suppliers were selected by participating brands (amongst others H&M and C&A). Large brands could use their size as leverage to commit suppliers to such a programme, and also pay part of the program cost, something that does not apply to MD. Nevertheless, MD could appeal to (nominated) suppliers through the closer and long term relationship it has cultivated;
- ◊ **Focus on cost reduction.** If a supplier reduces its resource consumption, naturally the cost for these resources, such as energy and water, will decrease. By calculating the return on investment (ROI), suppliers could be committed to reduce cost by acting sustainably;
- ◊ **Participation fee.** Suppliers paid a participation fee to cover part of the overhead cost of the programme. This way, suppliers are more committed

throughout to the programme. This fee was also taken into account in the ROI calculations;

- ◊ *Organising face-to-face meetings.* The Better Mill Initiative officially started with a kick-off event where suppliers and brands came together in China to start the project together. Goals for the programme were defined and presented at the kick-off event. During the programme, multiple training sessions and progress meetings with all participating suppliers and brands were held to share intermediary results. Finally, a closing event was organised where suppliers received a certificate. These events proved to be engaging to suppliers;
- ◊ *Collaboration with industry organisations.* For the Better Mill Initiative, Solidaridad collaborated with industry organisations, for example Clean by Design. Clean by Design focuses on improving process efficiency to reduce waste and emissions and improve the environment. According to Greer (2015), even marginal improvements in manufacturing factories have the potential to deliver excellent cost savings, while also decreasing environmental impacts. The employee also mentioned ZDHC, IDH (a sustainable trading initiative) and STWI (Sweden Textile Water Initiative) as potential future partners.

Two final remarks should be made. According to this employee, the strict regulations in China also helped to commit suppliers to the Better Mill Initiative. When legislation in China is further tightened, suppliers may see the need for sustainable practices. Lastly, the employee mentioned the possibility to apply for funding of the Dutch government (Fonds Verantwoord Ondernemen) to partially finance such a project.

CO₂ dyeing company

Using CO₂ to adhere dyestuff to textiles seems to be a promising innovation in sustainable textile dyeing. Besides the fact that this technology does not use or pollute water, there is another significant advantage. Dyeing with CO₂ seems to have a higher Right-First-Time (RFT) ratio. RFT with dyeing means that the target shade of textiles is achieved with the first time of dyeing, leading to shorter lead times and less resource consumption (Prashar, 2013).

However, the interview with the employee provided two restrictions that hamper the use of this innovation by MD:

- ◊ Currently, CO₂ dyeing is only used by fabrics that are completely made of polyester. This has to do with the fact that polyester is a hydrophobic

material which results in the fact that it is easier to dye polyester with CO₂ than with water. MD uses different fabrics, microfibers with elastane, making it hard to use this technology;

- ◊ A large investment in the factory is needed to implement this technology. CO₂ dyeing uses different machines (figure 31) to dye textiles. This means that a relatively large investment is needed to implement CO₂ dyeing. Currently, this company has sold 13 machines to 6 customers, often a brand contributed to the investment.



FIGURE 31. CO₂ dyeing machine
(H. Teeuwen)

It can be concluded that CO₂ dyeing will not be possible or feasible for MD in the coming years. If the technology becomes wider available in the future, it might provide an opportunity for MD to reduce environmental impacts, if it can be used with other fabrics such as nylon and elastane.

Tier 2 supplier

Another promising development in the textile industry is dope dyeing. In the supplier survey (paragraph "7/2 Survey"), one tier 2 supplier mentioned that it significantly reduced water and energy consumption by using dope dyeing. The employee mentioned that the most important reason for this tier 2 supplier to use dope dyeing is government legislation. For the same reason, the tier 2 supplier also switched from coal to gas as an energy source, installed a water treatment system and installed solar panels.

Even though it is true that dope dyeing reduces the environmental impacts of the supplier's production process, the environmental impacts of the production processes of the yarn supplier increase because of dope dyeing. With regular fabric dyeing, the yarn suppliers purveys undyed yarn to the tier 2 supplier, while with dope dyeing, the yarn supplier has to dye the yarn itself. Presumably, the environmental impacts of dope dyeing are still slightly lower than in fabric dyeing, but this could not be confirmed by the employee.

Apart from environmental impacts, three remarks on dope dyeing should be made:

- ◊ If a customer wants to order its own specific colour, there is a high minimum order quantity (moq). MD cannot work with such moq's because of the small order sizes and small amount of fabric used per product. To overcome this problem, the supplier offers a variety of colours that can be ordered in a smaller quantity;
- ◊ If a customer wants to order its own colour, a longer lead time is needed to deliver the fabric, because of the extra communication between the fabric and yarn supplier that is needed. Of course, this is not the case with the predefined colours, in that case the lead time is shorter, because the yarn is already dyed;
- ◊ The employee mentioned that dope dyeing is on average 20% cheaper than regular dyeing.

Tier 3 supplier

As a tier 3 supplier of MD, this company has a lot of insights in the whole supply chain. The tier 3 supplier is trying to improve sustainability in the textile industry. Its way of working can be described in four points.

- ◊ The tier 3 supplier develops chemicals that improve the RFT ratio of dyeing processes. Their goal is to improve textile wet processes on robustness to make them more reliable;
- ◊ The tier 3 supplier set up collaborations with brands to generate commitment of and leverage at suppliers;
- ◊ The tier 3 supplier has developed a wet processing simulator. This simulates a textile wet process to map overall cost reduction possibilities in a textile mill (e.g. by calculating reduced energy consumption);
- ◊ Through joint ventures with brands and textile mills, the tier 3 supplier invests in sustainable solutions.

Furthermore, the employee mentions a few other insights about the textile industry:

- ◊ CO₂ dyeing is still significantly more expensive than regular dyeing. Besides, it is a large investment. The employee does not expect this to be widely implemented in the short term;
- ◊ Textile mills are mainly driven by cost. Textile mills are in a competitive market, some might use sustainability as a competitive advantage. Also, government legislation might accelerate sustainable developments, but the main reason to implement sustainable solutions is still to reduce cost;
- ◊ Innovation in textile wet processing is driven by a demand from the industry;
- ◊ Sustainability improvements are often perceived to be costly, while it in fact could save cost. By reducing water and energy consumption, the water and energy costs decrease as well. This is a way for smaller brands with little leverage to positively affect their suppliers. Since textile mills are driven by cost, they are likely to be willing to participate in a sustainability programme that will lead to a lower resource consumption.

8|4 Conclusions

The industry experts provided useful insights on mainly three topics; CO2 dyeing, dope dyeing and collaborating with suppliers. Regarding CO2 dyeing, it can be concluded that this is not (yet) viable or relevant for MD. It is not widely available, too expensive due to high investment cost and not possible with fabrics used by MD.

Dope dyeing could be an interesting opportunity, however it is not completely clear what the actual environmental impacts of dope dyeing are. Furthermore, it would only be desirable for standard colours, since developing other colours demands higher moq's and longer lead times.

The expert interviews provided three interesting insights in collaborating with suppliers.

First, collaborations with tier 3 suppliers could be valuable. Tier 3 suppliers have a lot of specific knowledge on environmental impacts of textile wet processing and could provide insights in possible resource consumption. Second, even though sustainability is often associated as costly by tier 1 and tier 2 suppliers, the most evident way to increase sustainability is to reduce resource consumption, leading to cost reduction. By focusing on reducing resource consumption, suppliers could be engaged in a sustainability project. Last, to be able to commit suppliers for a long term project, it is important to organise meetings regularly to discuss progress and control the project.



Buckets with fabric dye at a tier 2 supplier in China

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- 10 Design requirements
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9 *Synthesis & problem statement*

All results from the discover phase are synthesised in this chapter, answering the first three research questions; 1| “How can sustainability be managed in a garment production supply chain?”, 2| “How is the current collaboration between MD and its tier 1 and tier 2 suppliers?” and 3| “How can the environmental impact of textile wet processes be decreased?”. Furthermore, this chapter defines the problem statement and the solution space that are the starting point for the develop phase.



9|1 Answering research questions

As described in paragraph "2|4 Project setup", the discover phase answers the first three research questions:

1| How can sustainability be managed in a garment production supply chain?

The literature study in chapter "1 Context" and chapter "3 Fashion industry & competitor analysis" answer this research question. There are three major issues that hamper sustainability in a garment production supply chain.

First of all, there is a lack of transparency and traceability. A garment supply chain is dispersed, hampering relationships with tier 2, 3 or 4 suppliers. MD has little to no insights in its tier 3 and tier 4 suppliers, (direct) competitors have the same struggles.

Second, the industry is complicated. Textile wet processing exists of extensive, technical processes that are hard to understand and it is difficult to measure and compare environmental impacts. There are various industry marks that are used by companies to measure environmental impact, however, measuring methods vary widely, making industry marks less reliable all together. MD is currently not using many industry marks, but this does not necessary have to be a problem.

Lastly, there is relatively little alignment within MD's supply chain. Sustainability can only be achieved by integrating social, environmental and economic goals within a supply chain. Even though MD has a closer relationship with nominated suppliers, a more intensive collaboration could help improve sustainability.

Concluding, the key to successfully managing sustainability within a supply chain lies in collaborating. Close collaborations with suppliers could lead to alignment within the supply chain and contribute to transparency, supporting sustainability improvements. Collaborations with other brands or specific industry organisations could help deal with the complexity of the production process and thus support sustainability improvements.

2| How is the current collaboration between MD and its tier 1 and tier 2 suppliers?

Chapter "4 Overview of MD's supply chain", chapter "5 Company & stakeholder analysis" and chapter "7 Supplier research" answer this research question. This research question is answered for tier 1 and tier 2 supplier separately.

Tier 1 suppliers

Regarding MD's relationship with tier 1 suppliers, two important remarks can be made. First, due to the complexity of the product, specific knowledge and expertise is needed from tier 1 suppliers. Due to the long term relationship MD has with its five most used tier 1 suppliers, this knowledge and expertise is present. A downside to this is that MD cannot easily switch to another supplier, it would take a lot of time and energy to cultivate similar relationships with other suppliers. Second, even though MD has relatively little leverage, MD employees visit tier 1 suppliers in China regularly, which contributes to a closer relationship with the suppliers. Also, all tier 1 suppliers signed a code of conduct, committing to MD's sustainability goals.

Tier 2 suppliers

Regarding MD's relationship with tier 2 suppliers, three remarks must be made. First, due to small order sizes, MD has even less leverage at tier 2 suppliers. The monetary value of MD's orders is too small to impact tier 2 suppliers by force. This means that other solutions are needed to commit tier 2 suppliers. Second, MD has nominated some tier 2 suppliers, meaning that it requires or recommend them to the tier 1 suppliers. This arises from the relationships MD has built with these suppliers in the past. These closer relationships with nominated tier 2 suppliers provide opportunities for supply chain alignment. Last, the cost of textile wet processing are relatively low, while the environmental impact of textile wet processing is relatively high. This means that an investment to significantly decrease environmental impact in the supply chain will not affect the consumer price as significantly.

3| How can the environmental impact of textile wet processes be decreased?

Suppliers, through factory visits, interviews and a survey, as described in chapter “7 Supplier research”, and industry experts, through interviews, as described in chapter “8 Industry expert interviews”, answer this research question.

Even though dyeing with CO₂ is a promising, sustainable development in textile wet processing, this is not (yet) a viable option for MD, due to high investment cost and the fact that is only possible with 100% polyester fabrics. Presumably, it will take a long time before this technology is widely available and implemented.

Dope dyeing could be a way to decrease environmental impacts of MD's products, although two remarks must be made. First, it is not yet clear what the actual environmental impact of dope dyeing is, this should first be researched. Second, MD would only be able to use predefined colours, due to the high moq with developing own colours. Also, in developing specific colours, lead times become longer. Concluding, if environmental impacts of dope dyeing are actually lower, MD could use dope dyeing for some basic colours, like black.

Looking at conventional dyeing methods, there are two main ways to decrease environmental impacts.

Firstly, the most evident way to decrease environmental impacts is to decrease resource consumption. By using less water, less chemicals and less energy, environmental impact decreases. Additionally, cost can be reduced as well.

Secondly, digital printing has a significant lower impact on the environment than screen printing. Using digital printing processes to print patterned fabrics would decrease the environmental impact of the product, but two things have to be kept in mind. Digital printing is a lot more expensive, meaning that profit margins decrease and/or consumer prices increase. Also, as described, digital printing prints on the fabric, leaving white stripes in between if the fabric is stretched out.

9|2 SWOT analysis

To synthesise all results from the discover phase, a SWOT analysis was executed. Based on all analyses described in the previous part, the strengths and weaknesses of MD regarding sustainability in its supply chain were

discovered. The SWOT analysis also describes the opportunities and threats in the fashion industry, regarding sustainability.

A SWOT analysis is usually used in early stages of an innovation process to generate insights in a company's strategic position (van Boeijen, Daalhuizen, van der Schoor, & Zijlstra, 2014). Besides, SWOT analyses can be used to promote group discussion about strategic issues and strategy development (Gürel, 2017). In this chapter, the SWOT analysis was used to summarise and structure findings from the discover phase, thus providing input on the design requirements. Furthermore, during a validation session with the Sustainability Project Group, the SWOT analyses was used to discuss insights gathered so far. Employees at MD confirmed results gathered, validating the analyses. Lastly, the SWOT was used during the brainstorm to substantiate the problem statement.

The results of this SWOT analysis can be found in table 3 on page 79. After every statement, the chapter(s) that it is based on are mentioned.

9|3 Problem statement

The final deliverable was defined in chapter “2 Setup” as:

A collaboration strategy, that can lead to improved production processes to decrease the environmental impact of MD's supply chain.

In the develop phase, this collaboration strategy is designed. This paragraph describes the problem statement that was defined on the basis of the weaknesses and threats from the SWOT analysis and used as a starting point in the develop phase.

It is important to write a concise but comprehensive problem statement to be able to define consistently clear and unambiguous design requirements (Shaffer, 2015). This is a requisite to be able to develop a successful solution.

It must be stressed that the ideal situation is not a realistic situation, but rather a vision to work towards.

Ideal situation

In the ideal situation, a sustainable supply chain would go without saying. All MD suppliers would be committed to produce products as sustainable as possible, progress would be measured with standardised measures and either consumers would be willing to pay for sustainable lingerie or suppliers would find ways to be sustainable without a significant increase in price.

Strengths

- ◇ MD signed a code of conduct with tier 1 suppliers, committing them to contribute to sustainability (chapter "5 Company & stakeholder analysis");
- ◇ MD has developed and is now executing its sustainability strategy. This includes providing transparency in the supply chain by signing the transparency pledge and the covenant of sustainable fashion and textile (chapter "1 Context" and chapter "3 Fashion industry & competitor analysis");
- ◇ MD has set up an internal sustainability project group that works on executing the sustainability strategy in collaboration with Rainbow collections (chapter "5 Company & stakeholder analysis");
- ◇ MD has a close relationship with tier 1 suppliers and regularly visits them in Asia (chapter "5 Company & stakeholder analysis");
- ◇ MD has closer relationships with nominated suppliers, who execute most textile wet processes (chapter "4 Overview of MD' supply chain").

Weaknesses

- ◇ Currently, MD has a narrow arc of integration and not much alignment in its supply chain (chapter "1 Context" and chapter "5 Company & stakeholder analysis");
- ◇ Because of its small size, MD has little leverage at suppliers, which might make it difficult to have an impact on them (chapter "5 Company & stakeholder analysis");
- ◇ With tier 2 suppliers that are not nominated, MD has little to no direct contact (chapter "5 Company & stakeholder analysis");
- ◇ MD has no insights in tier 3 and tier 4 suppliers (chapter "4 Overview of MD' supply chain").

Opportunities

- ◇ Aligning MD's supply chain could help improve sustainability (chapter "1 Context");
- ◇ Setting up collaborations with and/or between suppliers could accelerate an improvement of sustainability in the supply chain (chapter "1 Context" and chapter "3 Fashion industry & competitor analysis");
- ◇ Collaborating with other companies or other organisations could be useful to achieve an improvement of sustainability in the supply chain (chapter "3 Fashion industry & competitor analysis");
- ◇ The low cost of textile wet processing means that a small investment could have a relatively large impact on sustainability (chapter "4 Overview of MD' supply chain");
- ◇ Developments in dope dyeing instead of fabric dyeing could provide a solution to the environmental issues caused by textile wet processing (chapter "6 Textile wet process" and chapter "8 Industry expert interviews");
- ◇ Collaborating with tier 3 suppliers could strengthen a collaboration network (chapter "8 Industry expert interviews");
- ◇ Digital printing is significantly less harmful to the environment than screen printing (chapter "6 Textile wet process" and chapter "7 Supplier research");
- ◇ Decreasing resource consumption leads to decreased environmental impacts and reduced cost. This could be a way to engage suppliers (chapter "8 Industry expert interviews");
- ◇ Suppliers are looking for ways to exchange knowledge and learn from each other (chapter "7 Supplier research").

Threats

- ◇ The fashion industry in general deals with a lack of traceability and transparency in supply chains, which hampers impacting processes throughout the supply chain (chapter "1 Context");
- ◇ Because of the high variety of industry marks and the complexity of the fashion industry and of textile wet processing, measuring sustainability of a supply chain is very hard. This means that possible improvements are also hard to measure and therefore hard to value (chapter "3 Fashion industry & competitor analysis" and chapter "7 Supplier research");
- ◇ Chinese law regarding sustainability becomes more strict. The government could decide to close factories that do not perform well enough on sustainability issues. Two possible threats arise from this fact. First, if MD's suppliers are closed, either they have to be replaced or remaining suppliers should produce more. Second, if many suppliers are closed in China, this can put pressure on the total supply of fabric, which could increase prices (chapter "7 Supplier research" and chapter "8 Industry expert interviews");
- ◇ Suppliers do not have the same incentive as MD to act sustainably. This could hamper the support from suppliers (chapter "7 Supplier research" and chapter "8 Industry expert interviews").

TABLE 3. SWOT Analysis

(H. Teeuwen)

Furthermore, the supply chain would be fully transparent and all knowledge and expertise would be shared between suppliers.

Reality

In reality, there are four main issues that hamper the ideal situation:

- ◊ MD suppliers seem to be mainly driven by money. Other than cost reduction or force by legislation, suppliers have no incentives to improve sustainability. MD has too little leverage to force suppliers to improve;
- ◊ Often, but not necessarily, sustainability improvements cost money or require large investments in the short term. Therefore, it is often associated with expensive and costly;
- ◊ Textile wet processing, and the fashion industry in general, is complex. There are little standardised measurement methods and technical expertise is needed to fully understand, manage and improve these processes;
- ◊ The supply chain is not transparent and there is little alignment. MD does not know who its tier 3 and tier 4 suppliers are and tier 1 and tier 2 suppliers do not share any information or expertise with each other.

Consequences

These issues lead to the following consequences:

- ◊ MD does not have the expertise or resources to measure the current environmental impact and propose and implement improvements;
- ◊ Because of the complexity of the supply chain and the fact that MD does not have direct relationships with all tier 2 suppliers, it is difficult for MD to impact these businesses;
- ◊ Since suppliers hardly communicate with each other and the industry is so complex, suppliers use different measures to measure (environmental) sustainability.

Problem statement

Based on the ideal situation, the reality and the consequences, the problem statement can be defined as:

Due to the complexity of the production process, the lack of transparency in the supply chain and the absence of collaboration and communication between suppliers, MD can hardly improve the sustainability of the production process.

Proposal

Based on the strengths and opportunities defined in the SWOT analysis, the following three solution directions were formulated:

- ◊ Aligning MD's supply chain by closer collaborating with suppliers could improve sustainability. This is possible since MD has a close relationship with tier 1 suppliers and with nominated tier 2 suppliers. Also, it is in line with its sustainability strategy and the code of conduct;
- ◊ Suppliers are looking for ways to decrease cost to be able to survive in the competitive environment they are in;
- ◊ Suppliers are looking for ways to exchange knowledge and gather knowledge on environmental practices from other suppliers or independent organisations.

From these solution directions, the final solution space was defined:

A network of suppliers that enables them to share knowledge and expertise and collaborate on sustainability improvements.

Together with the design requirements defined in chapter "10 Design requirements", this is the starting point for the develop phase.

9|4 Conclusions

After the discover phase, the first three research questions could be answered.

For successful sustainability management in a garment supply chain, collaborations with suppliers are needed to overcome the lack of transparency, the complexity of the industry and the production process, and the lack of alignment.

Looking at current collaborations, MD already collaborates closely with tier 1 and with some tier 2 suppliers. Because of the long term relationships with and regular visits to tier 1 suppliers, MD has cultivated a close relationship with its tier 1 suppliers. This contributes to the leverage MD has over these businesses and might contribute to the suppliers' willingness to participate in a sustainability project.

With tier 2 suppliers, MD has less leverage due to the small size of the company. However, MD has selected nominated suppliers, with whom long term relationships are cultivated. This contributes to the leverage MD has over these businesses.

To improve sustainability specifically in textile wet processing, there are three possibly viable options. The most evident way to improve sustainability is to decrease resource consumption, leading to cost reduction. Dope dyeing might be a way to decrease environmental impacts, but this should be researched more thoroughly before implementing. CO₂ dyeing could be very promising, but is not feasible for MD in the short term.

A network of suppliers will be developed, that enables them to share knowledge and expertise and collaborate on sustainability improvements.

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10 *Design requirements*

This chapter provides the design requirements that the final solution should comply with.



Before the develop phase, design requirements are set up. The final solution has to comply with these requirements. These requirements are used after the deliver phase to evaluate the solution.

The design requirements are set up on the basis of the results of chapter “9 *Synthesis & problem statement*”. Also, in a validation session, the sustainability project group of MD provided input on the requirements.

The design requirements are defined as follows:

The developed strategy should...

- ◊ contribute to MD’s key ambitions;
- ◊ contribute to transparency in the supply chain;
- ◊ create internal and external support for sustainable development;
- ◊ make sure that possible agreements between MD and suppliers are complied with;
- ◊ contribute to alignment in the supply chain (between MD, tier 1 suppliers and tier 2 suppliers) regarding:
 - 1| information accessibility;
 - 2| responsibilities;
 - 3| interests;
- ◊ in no way harm social sustainability;
- ◊ group and unite tier 2 suppliers;
- ◊ be relevant to MD, taking the size of the business into account;
- ◊ be relevant to suppliers.

The design requirements are validated by the brainstorm in chapter “11 *Ideation & conceptualisation*”.

PART IV

Develop

11 Ideation & conceptualisation

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11|2 *Brainstorm*

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11 Ideation & conceptualisation

This chapter describes the design process and presents the conceptualisation of the final solution. In the ideation process, a brainstorm with MD employees generated inspiration, after which various ideas were generated and finally developed to a final concept. The explanation of the final concept answers research question 4| "How can MD strengthen the collaboration with its suppliers?".



11|1 Process

The ideation process generally consisted of three phases, as visualised in figure 32.

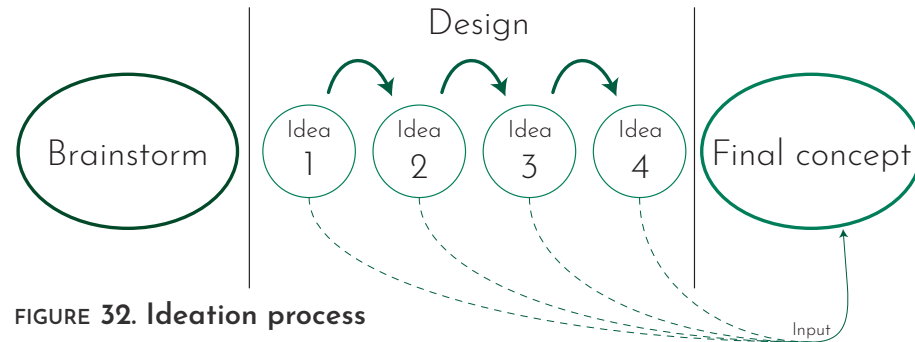


FIGURE 32. Ideation process

(H. Teeuwen)

First, a brainstorm with MD employees generated an inspirational starting point for the design phase. Also, the brainstorm pointed out several problems and risks that could occur when setting up a network. Second, during the design phase, four ideas were developed to solve the problems defined. Finally, different input from all these ideas were brought together in the final concept.

11|2 Brainstorm

Method

Brainstorming is especially useful to start up the generation of ideas after defining the design requirements (van Boeijen, Daalhuizen, van der Schoor, & Zijlstra, 2014). Ideation processes usually generate more ideas when executed in groups (Lamm & Trommsdorff, 1973). By forming a brainstorming team with MD employees with different roles and backgrounds, ideas can be generated from various perspectives.

This brainstorm session was facilitated using the Walt Disney method, a collaborative creativity technique, based on Walt Disney's way of working and thinking, using three different points of view to generate and evaluate solutions. Collaborative creativity is a common way to find novel ideas and it can be used as an important part of problem solving (Tausch, Steinberger, & Hußmann, 2015).

Goal

The goal of this brainstorm is threefold.

First, it is used to generate ideas and solutions for the problems defined in the problem statement. The outcomes are used as an inspiration in developing a collaboration model for MD. Some outcomes may be tangible results that can be implemented in a collaboration model, others may be inspirational ideas that need more elaboration.

Second, the goal of this brainstorm is to create and improve internal alignment and support for sustainability issues, by including MD employees from several departments.

Lastly, the goal of the brainstorm is to validate and possibly iterate the design requirements.

Setup

Everyone in MD's Sustainability Project Group, consisting of nine employees, participated in the brainstorm. Also, two other employees participated. As previously mentioned, these are people from different departments in MD.

During the brainstorm, the group was divided in three groups of three or four people. I did not participate, but switched between the three groups to facilitate and accelerate the brainstorming process. The setup of the afternoon was divided in six phases, which are described below.

- 1. *Introduction*
- Recap of design requirements and introduction to the Walt Disney brainstorming method. To structure ideas and help participants to start generating ideas, four questions are formulated:
- 30 minutes
 - ♦ What is the impact we aim to achieve?
 - ♦ How to create support amongst suppliers?
 - ♦ What collaborating solutions are possible?
 - ♦ How could a platform be realised?
- All groups got four flipover sheets with these questions written on them to use during the brainstorm, as shown in figure 33 on page 88.

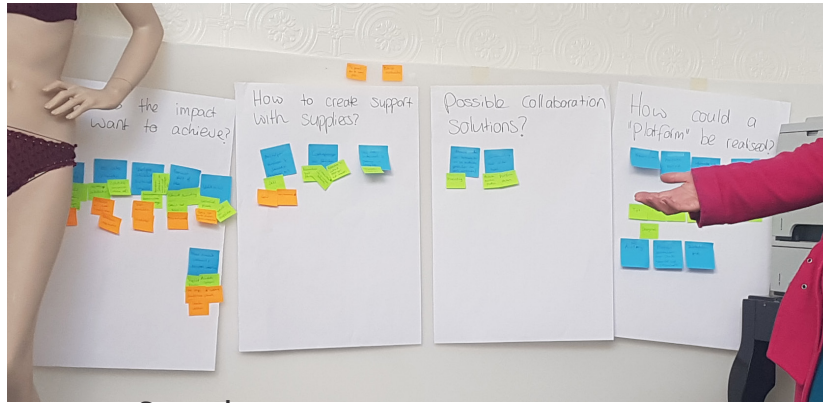


FIGURE 33. Setup brainstorm

(H. Teeuwen)

2. *Brainstorm phase 1: dreamer*

The goal in the first phase is to generate new ideas. Participants think of possible solutions to a problem and the benefits of those solutions. Participants write down solutions and ideas on blue sticky notes and stuck them on the flip over sheets. Four questions provide the starting point for this phase:

- ◊ What do we desire?
- ◊ What are possible solutions?
- ◊ How do we imagine the solution?
- ◊ What are the benefits of applying this solution?

3. *Brainstorm phase 2: realist*

The goal of the second phase is to concretise the ideas of the first phase. Participants evaluate ideas on feasibility and turn ideas into measurable action plans. Participants write down concrete actions steps on green sticky notes and put those solutions on the matching blue post it. Some blue sticky notes have multiple green sticky notes, some have none. Again, four questions are provided at the start of this phase:

- ◊ How can we apply this idea in reality?
- ◊ What is the action plan to apply the idea?
- ◊ What is the timeline to apply this idea?
- ◊ How to measure the outcome & output of the idea?

4. *Brainstorm phase 3: critic*

The goal of the last phase is to identify issues and address constraints of the ideas generated in the first two phases. Participants use orange sticky notes to write down constraints for every blue post it, answering the following questions:

- ◊ What could be hampering the idea?
- ◊ What is missing?
- ◊ Why would it not be applicable?
- ◊ What are the weaknesses in the plan?

Again, some ideas have multiple orange sticky notes, some have none.

5. *Timeline developing*

After three brainstorming phases, the teams organise all ideas on a timeline. This visualises how fast particular ideas could be implemented. The timeline was divided in three phases:

- 1| 0-1 years: solutions that are implementable within 1 year, short term solutions;
- 2| 1-5 years: solutions that are implementable within 1 to 5 years;
- 3| >5 years: solutions that are not implementable within 5 years (but probably later); long term solutions.

All sticky notes are taken off the original sheets and put on this timeline.

6. *Presenting and voting*

Finally, all groups present their timelines to the other groups. After the presentations, all participants receive three stickers to vote on the ideas that they believe are most promising.

Results

This paragraph provides a summary of the most important results of the brainstorm. Photos of all results can be found in appendix 9.

The first two phases, dreamer and realist, generated ideas, varying from broad and tenuous to specific and defined. The results of these phases are discussed in the following two paragraphs.

The last phase, critic, generated insights in possible risks to and weaknesses of the aforementioned ideas. The results of this phase are discussed in the last paragraph.

Inspiration

The brainstorm generated various ideas that could be used as an inspiration to me during the ideation phase. The ideas with the most votes and the ideas that were mentioned by two or more groups are listed below:

- ◊ *100% digital print.* Currently, a lot of printed fabrics are printed using screen printing, which is much more harmful to the environment than digital printing. During the brainstorm, one group proposed to only use digital printing in the future. However, two constraints were mentioned. First, a design commitment must be made. As described, digital printing results in a print on the fabric, leaving white stripes in between when the fabric is stretched. Second, digital printing is more expensive than screen printing, meaning that either the profit margin decreases or the consumer price increases (if all other components of the products stay the same);
- ◊ *Fully recyclable product.* As a long term project, two groups mentioned the development of a fully recyclable or recycled product. This can mean that all materials are recycled and recyclable, but it could also mean that MD switches to a new business model where it collects, reuses and recycles used products.
- ◊ *Inspiring customers, consumers and suppliers.* Multiple possible executions were mentioned. First, making a documentary about the brand mission of MD and how the products are produced could be a way to engage and inspire customers, consumers and suppliers. The group recognised that it would take a lot of manpower and money to produce a documentary. Second, blogs (for example on social media) could engage customers, consumers and suppliers in MD's sustainability mission. Third, a YouTube channel to inform customers and consumers on lingerie production was mentioned. Lastly, a website or internet forum was mentioned to inform customers, consumers and suppliers on MD's sustainability developments;
- ◊ *Researching and paying living wages.* A living wage is defined by Anker & Anker (2015) as "Remuneration received for a standard workweek by a worker in a particular [time and] place sufficient to afford a decent standard of living for the worker and her or his family. Elements of a decent standard or living include food, water, housing, education, healthcare, transport, clothing and other essential needs including provision for unexpected events." In general, the living wage is higher than the minimum wage. By

setting up a project, in collaboration with suppliers, to define the living wage of a factory employee in China and to pass this on to the price MD pays for products (or fabrics for tier 2 suppliers), MD improves social sustainability in the supply chain. However, a big risk that was mentioned is that it should be controlled to prevent abuse, to make sure the employees actually receive the added salary.

Supplier commitment

The brainstorm resulted in some promising ideas regarding supplier commitment. Most ideas were solutions to organise a network of suppliers. As potential ways to successfully set up a collaborative network of tier 1 and tier 2 suppliers, the following ideas were mentioned:

- ◊ *Collaboration with a local organisation such as an NGO, consultant or university.* A few advantages are mentioned. First, it could increase supplier engagement, since this organisation might be known to the supplier and based in the same area. Also, an organisation that has specific knowledge about textile wet processing could provide knowledge on managing and improving these processes. Furthermore, an organisation that is based in China could partly overcome the language barrier as many employees in factories do not speak English. Last, a local organisation could perform independent checks on the progress;
- ◊ *Collaboration with another brand.* This could be a lingerie brand that produces products in the same area in China as MD. If other brands, who use the same suppliers as MD could be engaged, the monetary leverage could increase. This way, MD and the other brand might be able to force suppliers to improve on sustainability. However, via the "open apparel registration", a platform where fashion brands share their suppliers, no comparable brands with corresponding suppliers could be found. Also no overlap in suppliers was found in the covenant of sustainable fashion and textile;
- ◊ *Collaboration with (local) governments.* This could help increasing supplier commitment and understanding and implementing continuously changing legislation. Also, subsidies of governments, in China or in the Netherlands, could help funding the development of a network organisation;
- ◊ *Collaboration with a charity.* This might be a possibility to invigorate such a collaborative network. It might also be possible to receive funding or subsidies via a charity.

Besides ideas regarding network organisation, some other promising, popular ideas were mentioned that were used as an inspiration in the ideation phase:

- ◊ *MD academy.* Setting up an “MD academy” or “lingerie school” to develop employees in factories could be a way to engage suppliers in a network, whilst improving social sustainability. Tier 1 suppliers employ mostly women. Setting up an educational program to train these women in the specific skillset needed to produce MD lingerie, or organising workshops to empower these women and improve their confidence would improve social sustainability and contribute to MD’s brand mission;
- ◊ *Sustainability awards.* Rewarding sustainability awards to suppliers who improve environmental and/or social sustainability could be a way to engage suppliers. This could for example be a small monetary reward to (employees of) factories that perform very well, but it could also be a contribution to a sustainable investment, such as water filters. Besides monetary rewards, MD could also hand out certificates to acknowledge the suppliers’ efforts;
- ◊ *Nominated suppliers.* As mentioned earlier, MD uses nominated suppliers that they have cultivated a good relationship with. During the brainstorm, one group mentioned that MD could try to become a “nominated customer” of these suppliers. This way, the relationship could be tightened and MD could probably appeal to this tight relationship in implementing sustainable solutions.

Risks

Some risks and pitfalls of specific ideas were already mentioned in the previous paragraphs. In addition, the brainstorm resulted in insights in some risks that might be applicable to any form of collaboration:

- ◊ *Money.* Money is needed for the execution of any sustainability project. MD is a relatively small brand and does not have the resources to make large investments;
- ◊ *Support.* Creating support with suppliers is a condition for success to any collaboration strategy. Without supplier commitment, no collaboration will be successful. The expert interviews highlighted the fact that most Chinese suppliers are mainly driven by cost reduction. Participating in a sustainability project initiated by MD should result in benefits for suppliers, preferably a cost reduction, to ensure a successful continuation of the project;

- ◊ *Culture.* Cultural differences and language barriers might hamper any network that is set up. Misunderstanding and misalignment could lead to undesired results;
- ◊ *Abuse.* Abuse of a sustainability project could hamper the goals of the project. Suppliers should be committed to the final goal of the project to prevent abuse and measures to control this should be set up before the project starts. Also, it should be ensured that agreements made between MD and suppliers are complied with.

11|3 Ideation

As mentioned in chapter “9 Synthesis & problem statement”, the solution space was defined as:

A network of suppliers that enables them to share knowledge and expertise and collaborate on sustainability improvements.

To design this network, first, stakeholders that could be included and their goals are defined. Then, the collaboration network is designed, tackling the problems mentioned in the problem statement and the risks addressed in the brainstorm, continuously iterating to finally deliver a collaboration network that would be a solution to all problems and that would comply with all design requirements.

Stakeholders

A distinction is made between essential stakeholders that must be involved for the network to be successful and supporting stakeholders that could strengthen the network, but whose participation is not a necessary condition for success.

All stakeholders and their main goals regarding sustainability are described in table 4 on page 91.

Problems tackled

The problem statement and the brainstorm defined seven problems and risks that the network should overcome:

- 1| Due to the complexity of the process, it is not clear how sustainability should be measured;
- 2| Due to the lack of transparency, MD does not know who its tier 3 and tier 4 suppliers are and thus cannot know how sustainable production processes at those suppliers are;

Stakeholder	(main) goal
Essential stakeholders	
marlies dekkers	◇ Develop a sustainable business model; ◇ Offer high quality products to customers for a reasonable price; ◇ Be financially sustainable.
Tier 1 suppliers	◇ Highest possible profit; ◇ Comply with regulations.
Tier 2 suppliers	◇ Highest possible profit; ◇ Comply with regulations.
Supporting stakeholders	
Tier 3 suppliers	◇ Highest possible profit.
Customers	◇ Highest possible profit; ◇ Content consumers; ◇ Sustainable product.
Consumers	◇ Affordable product; ◇ Sufficient quality, fit and design; ◇ Sustainable product.
(local) organisation, such as:	Different goals, such as:
◇ Solidaridad ◇ ZDHC ◇ Local consultant; ◇ Local university; ◇ An other (local) organisation with a sustainability purpose.	◇ Sustainable textile production; ◇ Safer chemical management practices in the textile industry; ◇ Profit; ◇ Conduct scientific research; ◇ Improve sustainability.
Other brand(s)	Depending on the brand, but probably: ◇ Sustainable production; ◇ Profit.

TABLE 4. Stakeholders

(H. Teeuwen)

TABLE 5. Link design requirements and problems

(H. Teeuwen)

- 3| There is little to no collaboration and communication between MD's suppliers. All suppliers have knowledge and expertise that is not shared;
- 4| Developing a network costs resources, mainly money and time. Since MD is a relatively small brand, MD does not have the resources to make large investments;
- 5| Suppliers should be committed to the network to make it successful. However, the main driver for suppliers is profit, and hence, the main driver to participate in such a project should be cost reduction;
- 6| Cultural differences might hamper the network, if the network is fully dependent on MD. Due to language barriers, time difference, geographical distances and cultural differences, managing this network would be difficult for MD. Also, there is a risk of misunderstanding and misalignment;
- 7| Abuse of the network might hamper the sustainability goals, so prevention and control are needed.

The link between these defined problems and the 9 design requirements set up in chapter 10 is described in table 5.

Design requirement	Problem link
<i>The developed strategy should...</i>	
contribute to MD's key ambitions;	2
contribute to transparency in the supply chain;	2, 3, 5
create internal and external support for sustainable development;	3, 4, 5, 6, 7
make sure that possible agreements between MD and suppliers are complied with;	2, 3, 6, 7
contribute to alignment in the supply chain (between MD, tier 1 suppliers and tier 2 suppliers) regarding: ◇ information accessibility; ◇ responsibilities; ◇ interests;	1, 2, 3, 5
in no way harm social sustainability;	6, 7
group and unite tier 2 suppliers;	3
be relevant to MD, taking the size of the business into account;	1, 4
be relevant to suppliers.	1, 3, 5

As shown, all defined problems are linked to at least one design requirement. The table shows which problems have to be solved to meet a certain design requirement. From this, two conclusions can be drawn. First, the brainstorm validated the design requirements. Second, by solving the described seven problems in the final concept, all design requirements are met. The final collaboration network was designed in 5 steps, which will be explained below.

Idea 1: simple network

A simple network of MD, tier 1 and tier 2 suppliers would look like figure 34 on page 93. This network could contribute to solving problem 1, 2 and 3, but this does not go without saying; MD would still have to push this network and actively commit suppliers to make this happen. Also, this network does not solve problems 4, 5, 6 and 7.

Idea 2: supplier commitment

To ensure commitment of suppliers and reduce resources that MD needs to invest to develop and maintain such a network, the network should not be dependent on MD. It is desirable that a network of suppliers is carried by suppliers and supported by MD, as in figure 35 on page 93. However, as the image shows, a gap in the middle emerges if MD does not carry the network. As mentioned, the main goal of tier 1 and tier 2 suppliers is profit, which can be achieved by cost reduction. An effective network will not emerge without MD's input and tier 1 and tier 2 suppliers have no incentive to set it up.

Idea 3: local organisation

Including a local organisation in the network could be a way to overcome problems 5, 6 and 7. A network could be set up by a local organisation and supported by MD, as in figure 36 on page 93. However, as shown, all relationships between suppliers and the organisation would have to emerge; they are not yet existing. This makes it harder to overcome problem 5, as it is probably harder to commit suppliers to a network developed by an organisation they do not know.

Idea 4: tier 3 supplier(s)

A way to solve problem 5, and partly solve problem 4, 6 and 7, could be to collaborate with a tier 3 supplier in setting up a network. The expert interview with MD's tier 3 supplier, shows that tier 3 suppliers are developing dyeing methods to reduce resources, leading to improved sustainability and cost

reduction. Also, tier 3 suppliers have expertise about chemical management that might be valuable in improving sustainability. A collaboration with a tier 3 supplier to set up a network is visualised in figure 37 on page 93. This could be a way to overcome problem 5, while also contributing to solving problem 1, 2, 3 and 4.

However, in the long term, supplier commitment could be hampered if the suppliers have no incentive to (partly) carry this project. Also, MD probably cannot spend the resources to facilitate such a network in the long term.

Idea 5: other brands, customers and consumers

Lastly, other brands, customers and consumers could be valuable stakeholders to support such a network. Regarding other brands, as mentioned, MD does not currently know which brands could be valuable. As far as MD knows, there are no comparable brands that would be suitable for a collaboration to set up a network. In the future however, it could be useful to include other brands.

Regarding customers and consumers, it would be valuable to increase transparency in the supply chain, production processes and sustainability. In setting up a supplier network, customers and consumers have little added value, though it could be interesting to include them in the long term to increase transparency in the supply chain and possibly inspire customers, consumers and suppliers to contribute to MD's mission.

Solution

Looking at all problems to overcome and possible solutions, it can be concluded that developing a supplier network cannot happen automatically or at once. This should be a long-term project that develops over different phases in order to eventually be able to set up a sustainable network that will be valuable to all stakeholders.

In the first phase, MD should focus on setting up the network and engaging suppliers. In the second phase, the focus should be on further building and strengthening the network. Finally, in the last phase, MD should focus on the continuation of the project and making sure that it remains valuable to all stakeholders.

Before the project starts, measurable indicators should be defined in collaboration with participating stakeholders. During the project, but especially on pre-arranged moments between phases, the project should be evaluated and possibly adjusted before continuing.

FIGURE 34. Idea 1 | simple network
(H. Teeuwen)

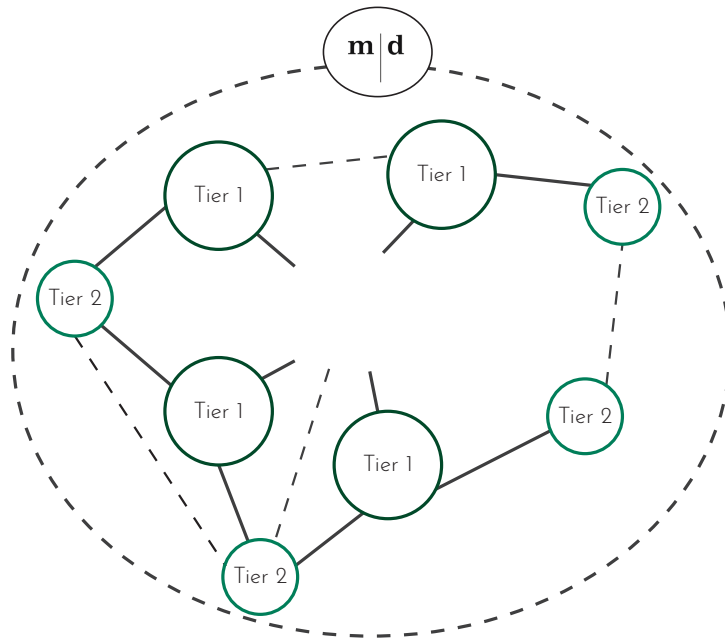
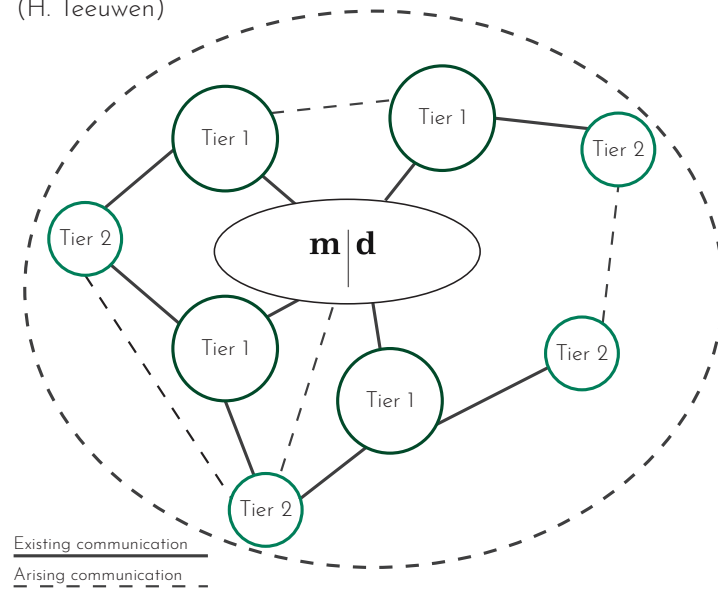


FIGURE 35. Idea 2 | supplier commitment
(H. Teeuwen)

FIGURE 36. Idea 3 | local organisation
(H. Teeuwen)

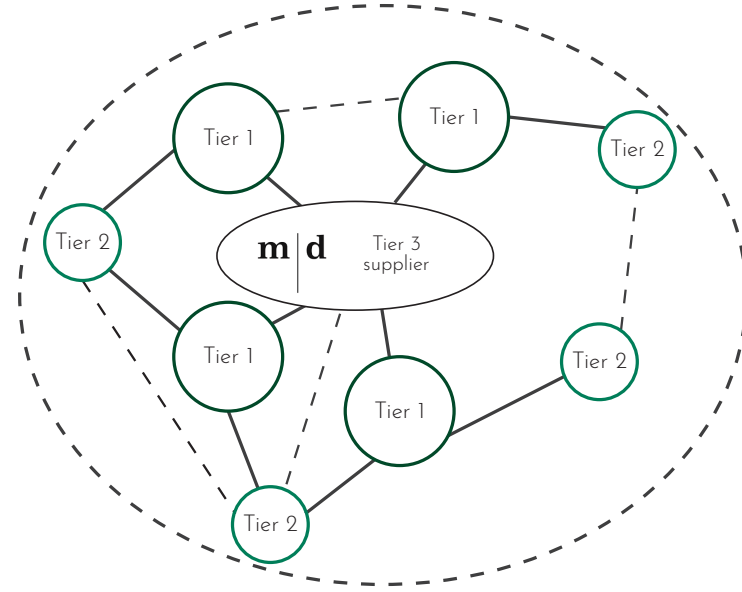
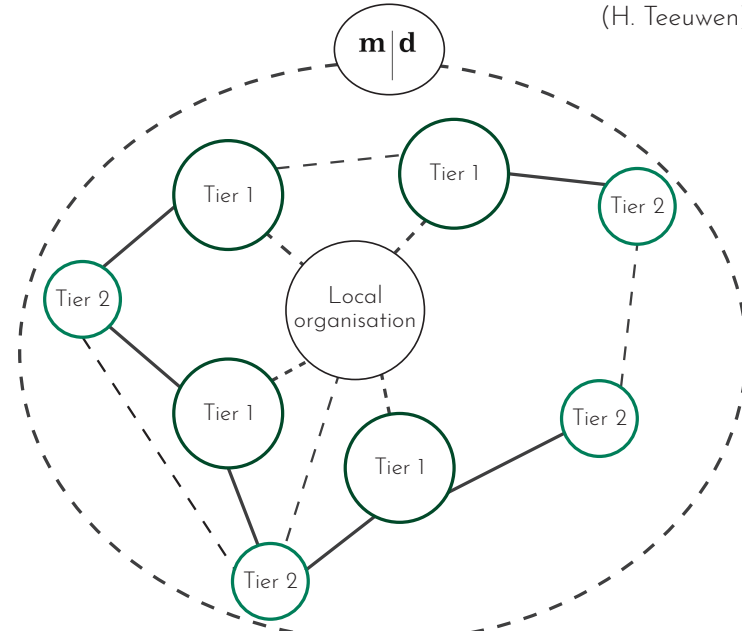


FIGURE 37. Idea 4 | tier 3 supplier
(H. Teeuwen)

From solution to final concept

All ideas described in the previous paragraph provided solutions to some of the defined problems, however, multiple phases are needed to eventually tackle all problems. From all ideas, various inputs were used to develop the final concept, as described in table 6. These inputs led to the development of the final concept.

11|4 Final concept

With the description of the final concept for the collaboration strategy, the fourth research question is answered.

4| How can MD strengthen the collaboration with its suppliers?

MD can strengthen collaboration with suppliers by setting up a network with and between them. To be able to successfully and sustainably set this up, this should happen in three phases, as visualised in figure 38 on page

TABLE 6. From solution to final concept

(H. Teeuwen)

Idea	Problems tackled	Inputs for final concept
1 Simple network (figure 34)	1, 2, 3	◇ A network of suppliers does not emerge out of nowhere, active input is needed; ◇ In the long term, MD cannot facilitate this network, because it does not have the resources to do so. Also, this would hamper supplier commitment.
2 Supplier commitment (figure 35)	1, 2, 5	◇ Giving suppliers more responsibilities is a way to increase supplier commitment, however suppliers need clear incentives to join and (partly) carry a network.
3 Local organisation (figure 36)	5, 6, 7	◇ Including a local organisation in the network is useful to strengthen the network, but less useful to set up the project, since this could hamper supplier commitment if suppliers do not have an existing relationship with the organisation.
4 Tier 3 supplier (figure 37)	1, 2, 3, 5, 6, 7	◇ Collaborating with a tier 3 supplier is useful to set up the network, but it might not be a sustainable long term solution, since both MD and the tier 3 supplier cannot invest the resources needed to manage this. Also, in the long term, this solution might hamper supplier collaboration, if the network is not carried by suppliers.
5 Other brands, customers and consumers	1, 2, 4	◇ Including other brands could be useful, but only if the other brands are comparable with MD and preferably use the same suppliers or suppliers in the same region; ◇ Including customers and consumers could inspire suppliers and vice versa. Also, it could contribute to sustainability.

95. The execution of the three phases will be further elaborated on the following pages. This elaboration will explain the goal of each phase and MD's required actions to reach this goal. Also, key performance indicators are described that can be used to evaluate the project after every phase.

Set up

Goal

The goal of the first phase is to establish a network with tier 1 and tier 2 suppliers. To engage them in this project, the network should be set up in collaboration with a tier 3 supplier. In the first phase, the project should focus on decreasing resource consumption, so that there is an incentive for tier 1 and tier 2 suppliers to participate.

Actions

- ◇ MD needs to define the fee that suppliers will have to pay to participate in this project. This income can be used to facilitate the network, e.g. paying for overhead costs such as renting a venue for a meeting. Also, by paying a fee, suppliers are more committed to this project;
- ◇ In collaboration with tier 2 suppliers and the tier 3 supplier, MD should

Set up

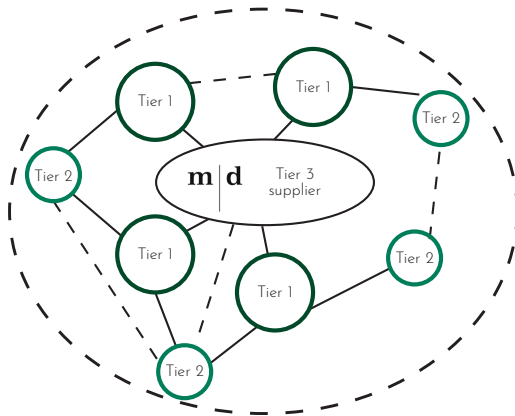


FIGURE 38. Final concept
(H. Teeuwen)

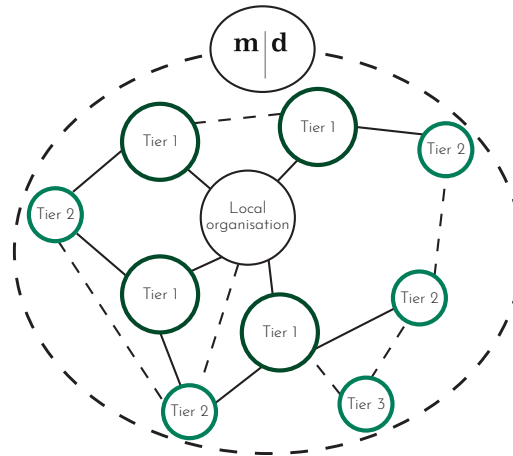
facilitate ROI calculations. Before suppliers participate in this project, it should be clear how much cost reduction can be achieved within what timeframe in relation to the fee paid. This way, suppliers have a clear incentive to participate in the project;

- ◇ MD should organise a kick-off meeting and set up a detailed planning, in consultation with suppliers, to yearly have two or three meetings with all participating stakeholders. Also, each supplier individually should formulate measurable goals for the first phase(s) of the project.

Key performance indicators

- ◇ Amount of tier 1 suppliers participating;
- ◇ Amount of tier 2 suppliers participating;

Build



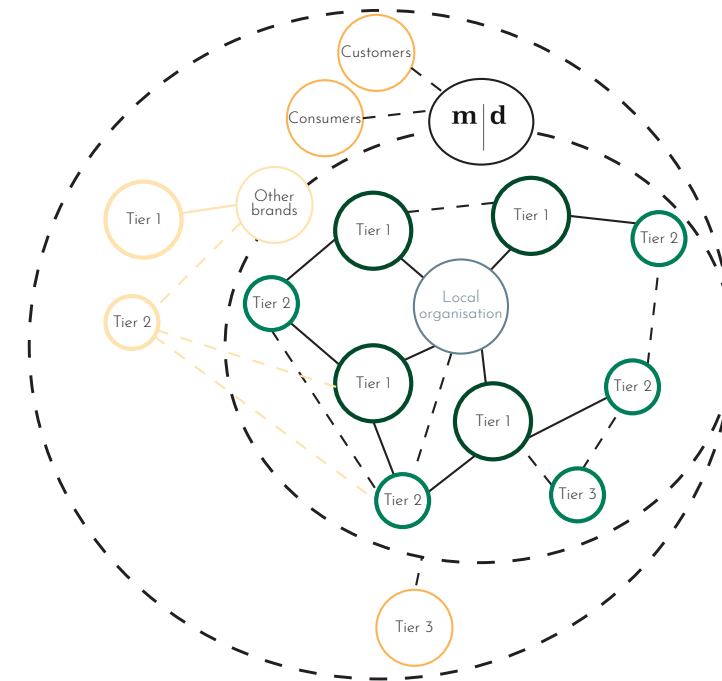
In consultation with MD, it was decided that during the first phase, at least one tier 1 supplier and two tier 2 suppliers should participate to make it a valuable project to MD.

Build

Goal

The goal of the second phase is to strengthen the network and prepare it for the third phase. An independent, local organisation should be involved to overcome cultural differences and to control the project. In this phase, suppliers become more responsible for maintaining the network, for example by hosting and organising meetings.

Continue



Actions

- ◇ MD should find and engage a local organisation to support the project. This could be done in collaboration with for example the local partner, Solidaridad, the covenant of sustainable fashion and textile or the Dutch embassy in China. Any of these mentioned organisations could act as the project supporter itself, or help MD to find a project supporter;
- ◇ MD should introduce clear measures for environmental impact that all suppliers should adopt. As mentioned, there are currently no clear measures to measure environmental impact. In collaboration with the local organisation, MD should define and carry through measures to measure environmental impact in the supply chain;
- ◇ MD should encourage participating suppliers to take on more responsibilities, for example by asking them to organise a project meeting;
- ◇ MD should evaluate the goals that were set by each supplier individually at the start of the project. Also, future goals should be defined with each supplier;
- ◇ In collaboration with participating tier 1 and tier 2 suppliers, MD should engage more suppliers to strengthen the network;

Key performance indicators

- ◇ The participation of at least one local organisation that controls the network;
- ◇ Amount of initiatives by suppliers;
- ◇ Amount and content of meetings;
- ◇ Amount of suppliers that use defined measures correctly;
- ◇ Resource (and cost) reduction of suppliers;
- ◇ Amount of tier 1 and tier 2 suppliers that participate in the project.

In consultation with MD, it was decided that during the second phase, at least two tier 1 suppliers and three tier 2 suppliers should participate to make it a valuable project to MD.

Continue

Goal

The goal of the last phase is to set up a sustainable network that can continue and grow in the long term. The role of the local organisation could become less vital and suppliers take on more responsibility. In the long term, MD could collaborate in this network with other brands and their suppliers. Also, more tier 3 suppliers could be involved. Lastly, MD could decide to

include customers and consumers in this network, increasing transparency in the supply chain.

Actions

- ◇ In collaboration with participating tier 1 and tier 2 suppliers, MD should engage more suppliers to strengthen the network;
- ◇ MD should consider collaborating with other brands to strengthen and further develop the network;
- ◇ MD should consider to share (part of) the network with customers and/or consumers;
- ◇ MD should evaluate the goals that were set by each supplier individually at the start of the project. Also, future goals should be defined with each supplier.

Key performance indicators

- ◇ Amount of initiatives by suppliers;
- ◇ Amount and content of meetings;
- ◇ Amount of suppliers that use defined measures correctly;
- ◇ Resource (and cost) reduction of suppliers;
- ◇ Amount of tier 1 and tier 2 suppliers that participate in the project.

In consultation with MD, it was decided that during the second phase, at least two tier 1 suppliers and four tier 2 suppliers should participate to make it a valuable project to MD.

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12 Impact measurement

This chapter describes the impact MD can make by developing the network as described in paragraph "11|4 Final concept". The chapter describes the impact value chain, that in five phases describes the goal of the project, the outcomes and impact of the project, the outputs of the project and the activities and inputs that are needed for the project.



Chapter “11 Ideation & conceptualisation” explains the final concept of the collaboration strategy. To invigorate this concept, this chapter describes the impact measurement of the project. By properly describing the impact of the project, MD can justify the investments in the project. Also, by describing the impact, MD can communicate the outcomes to customers and consumers, improving transparency in its supply chain.

12|1 Definition

Impact is defined as “the portion of the total outcome that happened as a result of the activity of the venture, above and beyond what would have happened anyway” (Clark, Rosenzweig, Long, & Olsen, 2004). It is important to recognise that an organisation’s impact should be measured beyond things that would have happened anyway. The things that would also happen without MD’s actions should be measured or estimated to be able to measure the actual impact of an action or project.

Clark et al. (2004) use the impact value chain to describe an organisation’s impact (figure 39). It shows how impact is created in five phases. The following paragraphs explain all the phases of the impact value chain, starting at the aligned goal to achieve and working back to the inputs needed.

Aligned goal

As mentioned in chapter “1 Context”, within a supply chain, interests and incentives should be aligned (Lee, 2004). To successfully set up a network with suppliers, it is important that the goal for all stakeholders to set up the network is aligned and that all stakeholders are committed to this goal. That way, the effort of organisations to optimise their goal contributes to the goals of all stakeholders in the supply chain (Lee, 2004).

As discussed in chapter “9 Synthesis & problem statement”, the most evident way to reduce environmental impacts is to reduce resource consumption. Reduced resource consumption naturally leads to cost reduction, which is an incentive for suppliers. Therefore, the aligned goal of this project is defined as:

Decrease physical resource consumption at suppliers

Physical resources are for example water, energy and chemicals. This goal captures the main goals of all stakeholders as described in table 4 on page 91.

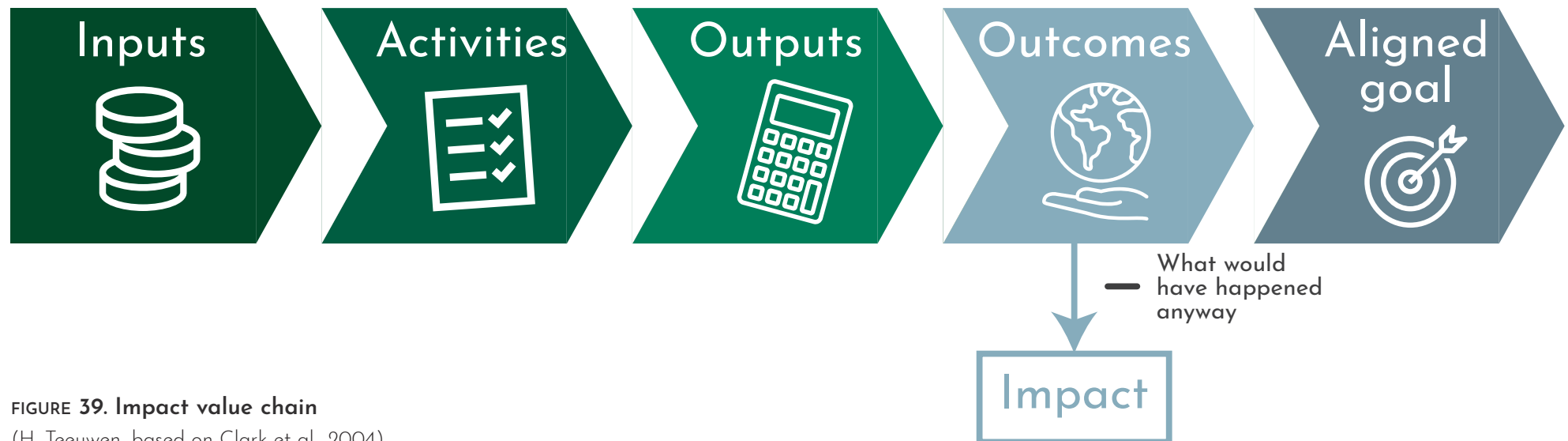


FIGURE 39. Impact value chain
(H. Teeuwen, based on Clark et al., 2004)

Outcomes

Clark et al. (2004) define outcomes as “the ultimate changes that one is trying to make in the world”. The outcomes, minus what would have happened anyway, describe the impact that an organisation makes. It is a qualitative result and therefore hard to measure. It is important to define desired outcomes at the beginning of the project, take a baseline measurement and evaluate the outcomes with another measurement. Unlike the aligned goal, outcomes can vary per stakeholder. A distinction is made between individual outcomes and broad outcomes.

Individual outcomes

For MD, developing this network could contribute to a better understanding of environmental impacts in the supply chain. This could help executing sustainability strategies. Also, developing this network would contribute to transparency in supply chain.

For all suppliers, the project could have the same outcome, namely increasing the understanding of environmental impacts in their production process and increasing their willingness to improve sustainability. This is something that can be measured at the beginning of the project with a baseline measurement, via a survey or interviews with suppliers or supplier employees. It can be evaluated after the successful implementation of the network by repeating the survey or interviews and measuring the difference.

For a local organisation the project could also contribute to a better understanding of environmental impacts in production process and to the mission of the organisation, but it is dependent on what organisation this will be.

Broad outcomes

As a broader outcome, developing such a supplier network could contribute to a more sustainable and more transparent fashion industry in general. By executing this project MD could inspire other companies to act more sustainably as well. This is something that is hard to define and to measure.

Impact

The impact of the project is defined by the outcomes, minus what would have happened anyway. Stricter Chinese legislation and an increasing demand for sustainable apparel could also contribute to a broader understanding of environmental impacts in the supply chain and to a more sustainable fashion

industry. The impact that legislation and demand have on the mentioned outcomes should be measured to be able to define the actual impact of developing a network.

Outputs

Clark et al. (2004) define outputs as “results that a company, nonprofit or project manager can measure or assess directly”. As suggested in the description, these are quantitative results that can be measured more easily. Outputs are often more specific and the results can be judged relatively easily. Again, it is important to set goals for outputs at the beginning of the project and evaluate them during the project. These goals should be specific, measurable, achievable, relevant and time-bound (SMART) in order to contribute to meaningful outcomes (Doran, 1981). Like outcomes, outputs can, and most certainly will, vary per supplier.

The most important outputs for MD are participating suppliers and a possible cost reduction.

The most important outputs for suppliers are a decrease in water pollution, water use, chemical use and energy use. These outputs lead to a cost reduction. These outputs cannot yet be SMART defined, because in order to do so, it is necessary to be able to measure water pollution, water use, chemical use and energy use. After clear measures are defined and implemented, SMART goals can be defined.

Activities

Activities are the primary actions that each stakeholder takes to eventually achieve outputs and outcomes and to contribute to the aligned goal. These are clearly defined and specific actions, devoted to specific stakeholders. The most important activities for MD include engaging stakeholders and managing the network. The most important activities for suppliers are measuring and sharing resource consumptions and attending meetings. The most important activities for the tier 3 supplier are supporting ROI calculations and attending meetings.

All activities that are needed to develop the network are elaborated further in chapter “13 Roadmap & implementation plan”.

Inputs

Inputs are defined as “the resources (money, staff time, capital assets, etc.) required to operate the venture or organization” (Clark et al., 2004). Basically, these are the resources needed to execute the activities that are needed to achieve outputs and outcomes. It is important that during the project, all stakeholders are willing to invest the inputs to contribute to the aligned goal. The most important inputs are money, investments by MD and fees paid by suppliers, and time, to manage the network, attend meetings and execute ROI calculations.

All inputs that are needed to develop the network are elaborated further in chapter “13 Roadmap & implementation plan”.

12|2 Impact value chain

Table 7 on page 101 shows the impact value chain for this project. It is important to stress that this still needs to be further defined at the start of the project. Suppliers should be involved to clearly define SMART outputs. Also, depending on the local organisation that would be involved in this project, inputs, outputs and desired outcomes should be formulated.

	Input 	Activities 	Output 	Outcome 	Goal 
m d	- Investment to organise kick-off meeting; - Time to recruit suppliers and manage network;	- Engaging suppliers in a network by: - Organising (kick-off) meeting(s); - Calculating ROI for suppliers. - Manage network.	- Participating suppliers; - Increased revenues/cost reduction.	- Understanding of environmental impacts in supply chain; - Transparency in supply chain; - A more sustainable fashion industry.	Decrease physical resource consumption at suppliers
Tier 1 suppliers	- Fee to organise meetings; - Time to measure data.	- Measure and share resource consumption; - Attend (kick-off) meeting(s).	- Less water pollution; - Less water use; - Less chemical use; - Less energy use; - Cost reduction.	- Understanding of environmental impacts in production process; - Willingness to improve sustainability.	
Tier 2 suppliers	- Fee to organise meetings; - Time to measure data; - Investment in process optimisation.	- Measure and share resource consumption; - Attend (kick-off) meeting(s).	- Less water pollution; - Less water use; - Less chemical use; - Less energy use; - Cost reduction.	- Understanding of environmental impacts in production process; - Willingness to improve sustainability.	
Tier 3 supplier(s)	- Fee to organise meetings; - Time to support ROI calculations.	- Support MD in ROI calculations; - Attend (kick-off) meeting(s).	Increased customer base.	- Understanding of environmental impacts in production process; - Willingness to improve sustainability.	
Local organisation	Depending on the local organisation.	Depending on the local organisation.	Depending on the local organisation.	- Understanding of environmental impacts in production process; - Contribution to organisation's mission; - A more sustainable fashion industry; - Depending on the local organisation.	

TABLE 7. Impact value chain

(H. Teeuwen, based on Clark et al., 2004)

PART V

Deliver

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13 Roadmap & implementation plan

The contents of this chapter are confidential and therefore only a small part is published. With the implementation plan, this chapter answers research question 5| "How can MD implement the collaboration strengthening solutions?"



13|1 Design roadmapping

To support the final concept explained in paragraph “11|4 Final concept”, a roadmap is delivered. This roadmap supports MD’s innovation strategy, by visualising the creation, exploration and convergence of ideas about the future (Cooper & Edgett, 2010). In fact, the roadmap visualises and explains MD’s sustainability strategy, setting up a collaboration network is a project that supports this strategy.

Goal

The final concept as described in chapter “11 Ideation & conceptualisation” is mainly focused on decreasing resource consumption in textile wet processing. Even though this does indeed contribute to MD’s CSR strategy, a supplier network, as described in the final concept, could be a foundation for a wider adoption of sustainability and supply chain innovation in general. The goal of this roadmap is thus to apply the final concept to the entire supply chain to manage sustainability holistically.

Definition

A roadmap is defined as “a visual portray of design innovation elements plotted on a timeline” (Simonse, Hultink & Buijs, 2015). A roadmap maps several elements, user values, market segmentations, product/service innovations and technology applications, on a timeline (Simonse, 2017). A roadmap is developed by defining a future vision and a time pacing that are used to map the aforementioned elements on. The final roadmap is confidential.

13|2 Implementation

To implement this strategy, a thorough implementation plan to develop the network is written.

13|3 Project management approach

Definition of project management

The development of the network described in chapter “11 Ideation & conceptualisation” is a project that supports the collaboration strategy described in chapter “13 Roadmap & implementation plan”. A project is defined as having the following characteristics:

- ◊ “Complex and numerous activities;
- ◊ Unique- a one-time set of events;
- ◊ Finite-with a begin and end date;
- ◊ Limited resources and budget;
- ◊ Many people involved, usually across several functional areas in the organizations;
- ◊ Sequenced activities;
- ◊ Goal-oriented;
- ◊ End product or service must result.”

(Weiss & Wysocki, 1992, p.3)

The development of the network meets all these characteristics. Therefore, this project can be implemented using the project management approach.

Phases of project management

Weiss & Wysocki (1992) describe five stages of a project management life cycle, visualised in figure 41 on page 106 and explained below.

- 1| Define: the context is analysed and the problem to solve is defined.
- 2| Plan: the solution is developed and elaborated in detail.
- 3| Execute: everything that is planned in the previous phases is carried out.
- 4| Control: parallel to the execution of the project, is checking and controlling everything. Planning, progress and budget should be measured and the project should be controlled. Also, the control phase needs to make sure that agreements between stakeholders are complied with;
- 5| Close: the evaluation of the project is evaluated and decisions on how to continue are taken.

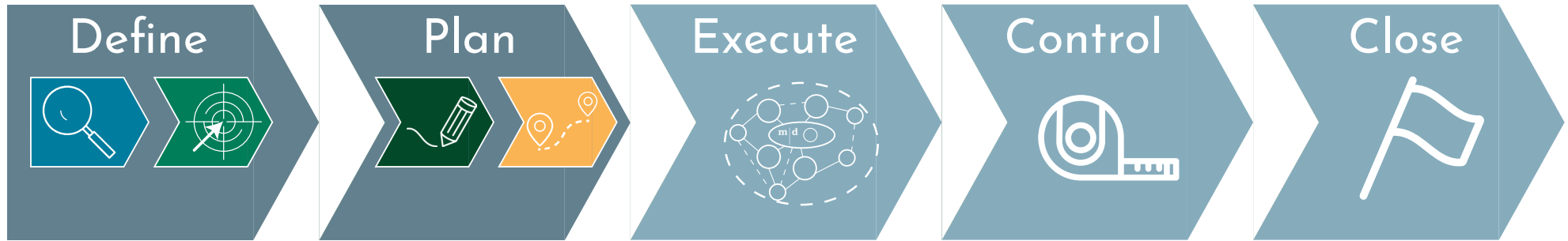


FIGURE 40. Project management approach
(H. Teeuwen, based on Weiss & Wysocki (1992); Vargas, 2007)

As visualised in figure 41, stage 1 is already partly executed by the develop and deliver phases of this thesis and stage 2 is already partly executed by the discover and define phases of this thesis. This chapter provides the final part of the plan stage by describing an implementation plan for the last three stages.

Iterative character of project management

Even though the project management approach is sequentially visualised in figure 41, the process of executing a project is in fact much more parallel

and iterative. As proposed in chapter “11 Ideation & conceptualisation”, the network should be set up in three phases; “set up”, “build” and “continue”. Using the project management approach to develop this network, each of the three phases could be considered as a project itself. Every phase should clearly be defined and planned, then be executed and controlled and finally finished. After the closure of every phase, the definition and planning should be revised to increase chances of success for the next phase. This iterative process is visualised in figure 40. Note that the execution and control stage are simultaneously executed.

The detailed implementation plan is confidential.

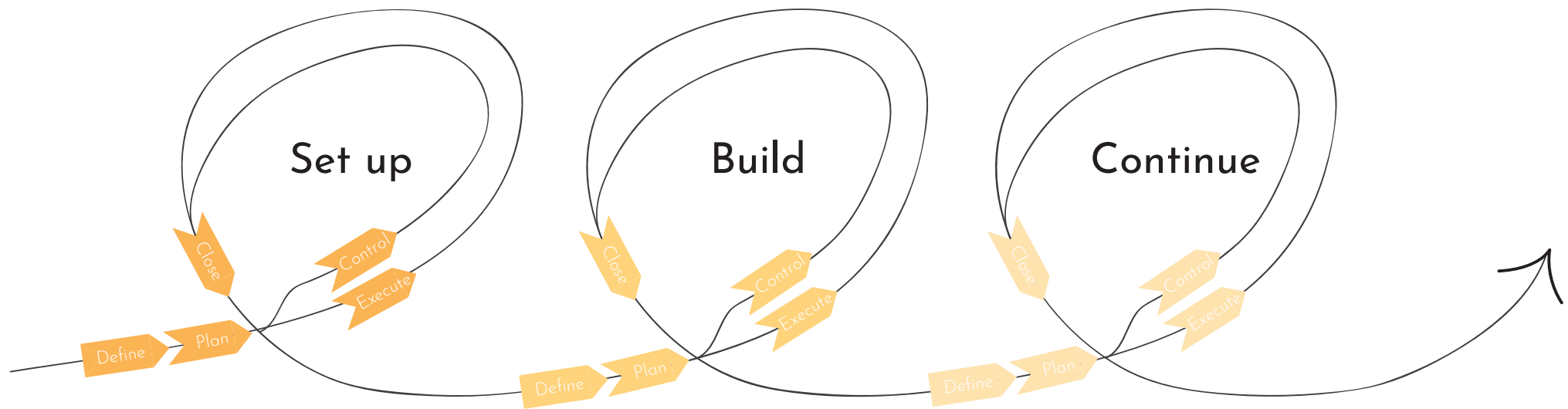


FIGURE 41. Iterative character of project management
(H. Teeuwen, based on Weiss & Wysocki (1992); Vargas, 2007)

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14 *Conclusions, discussion & recommendations*

This chapter concludes this thesis by evaluating the final concept. Also, a discussion is written that describes the limitations of the research. The last paragraph provides recommendations to MD to further improve sustainability, recommendations for further scientific research and recommendations for further interfaculty research.



14|1 Conclusions

The design challenge was defined as:

How can marlies/dekkers collaborate with suppliers in its supply chain to decrease the environmental impact of its textile wet processes?

By implementing a collaboration model in the form of a network, as described in chapter "13 Roadmap & implementation plan", MD can develop a collaboration with suppliers that supports the decrease of environmental impact.

The final concept of the collaboration model as described in chapter "11 Ideation & conceptualisation", the roadmap as described in chapter "13 Roadmap & implementation plan" and the implementation plan as described in chapter "13 Roadmap & implementation plan" together form the final deliverable, namely:

A collaboration strategy, that can lead to improved production processes to decrease the environmental impact of MD's supply chain.

The collaboration strategy contributes to transparency, alignment and integration in the supply chain providing opportunities to increase environmental and social sustainability in the supply chain.

Evaluation

The final concept is evaluated in two ways. First, the concept is evaluated on the design requirements. Second, the concept is evaluated on feasibility, viability and desirability.

Design requirements

The final concept is evaluated on the design requirements described in chapter "10 Design requirements". Table 8 on page 109 explains how the final concept complies with all design requirements.

Feasibility, viability & desirability

To evaluate the relevance of the delivered strategy, the strategy is evaluated on feasibility, viability and desirability. Figure 42 visualises how relevance is achieved in the overlap of feasibility, viability and desirability.

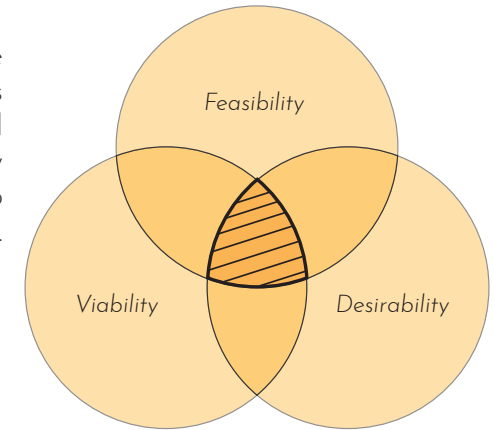


FIGURE 42. Feasibility, viability & desirability

(H. Teeuwen)

Feasibility refers to how realistic a proposed solution is. Looking at the collaboration strategy, a few factors contribute to its feasibility:

- ◊ Collaborations with a tier 3 supplier and (a) local organisation(s) contribute to supplier commitment and decrease the resources that MD needs to invest to develop the network;
- ◊ Committing suppliers by making them partly responsible for the network contributes to the feasibility. Instead of MD trying to force a network on suppliers, MD develops the network together with suppliers.

Viability refers to the ability of the solution to survive on the long term. Looking at the deliverable of this thesis, the following factors contribute to its viability:

- ◊ By developing the network with an aligned goal for all stakeholders, reducing resource consumption, all stakeholders have the incentive to actively participate;
- ◊ By developing the network in three phases over six years, it has time to grow and become an integrated part of the relationships with and between suppliers. This way, after developing the network, communication and transparency in the supply chain become more self-evident.

Design requirement <i>The developed strategy should...</i>	Explanation	
contribute to MD's key ambitions (being fair and equal, find sustainable solutions, be transparent, empower women).	The final strategy contributes to MD's key ambitions. Setting up a supplier network increases transparency in the supply chain. Also, it supports finding sustainable solutions. By using this network to increase social sustainability, as described in the roadmap, it contributes to being fair and equal and to empowering women.	✓
contribute to transparency in the supply chain.	Closer collaboration with suppliers leads to more transparency in the supply chain, as MD has better insight in sustainability issues. Also, by including customers and consumers in the network, transparency in the supply chain is increased.	✓
create internal and external support for sustainable development.	Within MD, this project will be executed and evaluated by the Sustainability Project Group, contributing to internal support. Strongly engaging suppliers to the network, by aligning the goal, asking a fee and giving them responsibilities, contributes to external support.	✓
make sure that possible agreements between MD and suppliers are complied with.	Including a local organisation in the network helps to control agreements with suppliers. Also, by aligning the goal of the project, suppliers will be more likely to comply with agreements made.	✓
contribute to alignment in the supply chain (between MD, tier 1 suppliers and tier 2 suppliers) regarding: ♦ information accessibility; ♦ responsibilities; ♦ interests.	Increasing transparency in the supply chain and strengthening collaborations with suppliers both contribute to aligning information accessibility. On the one hand, MD can easier gather information from suppliers, and suppliers can probably forecast better with information from MD. Proper communication in the network contributes to the alignment of responsibilities. Lastly, by defining an aligned goal, interests are also aligned.	✓
in no way harm social sustainability.	As shown in the roadmap, this network could also contribute to social sustainability. By strengthening the collaborations with suppliers, MD gets more grip on social sustainability as well.	✓
group and unite tier 2 suppliers.	Initially, during the set up of the network, not yet many tier 2 suppliers are involved. Later during the project, tier 2 suppliers become involved and the network would unite them. In the long term, tier 2 suppliers can be segmented on size to manage sustainability at those suppliers accordingly.	✓
be relevant to MD, taking the size of the business into account.	By setting up the network in a way that MD is not solely responsible for managing and facilitating this, the solution is both relevant and realistic to MD.	✓
be relevant to suppliers.	By aligning the goal of the network to the main goals of suppliers, this solution is relevant to suppliers.	✓

TABLE 8. Evalutation final concept

(H. Teeuwen)

Desirability refers to how the proposed solution addresses the values and needs of all stakeholders included. Including various stakeholders in the process helped increasing desirability. The development of the network addresses the needs of stakeholders in the following ways:

- ◊ MD wants to increase sustainability of its products. By increasing transparency and strengthening supplier relations, MD has the opportunity to better measure and control the sustainability of its products;
- ◊ Tier 1 and tier 2 suppliers are both in a competitive landscape in China, where legislation forces them to act more sustainably. The network provides an opportunity to collaboratively improve sustainability. This supports legislation compliance and provides a competitive advantage when the demand for sustainable fashion grows;
- ◊ Tier 3 suppliers want to increase their revenues while providing more sustainable dyeing solutions to their customers (tier 2 suppliers). The network allows tier 3 suppliers to share and gather knowledge on how to improve sustainability. Also, it connects tier 3 suppliers with possible new customers;
- ◊ Customers and consumers increasingly demand sustainable and traceable fashion. The network contributes to transparency in the supply chain, leading to increased traceability for customers and consumers. Also, the network could lead to a more sustainable product;
- ◊ The needs of the (local) organisation depend on the organisation that is acquired to support the network. However, it is recommended to involve a supplier whose needs and values match the values that the network delivers.

14|2 Discussion

Supply chain integration

Executing a project as proposed by this thesis, would increase supply chain integration. As mentioned, the integration of key business processes from end user through original suppliers contributes to successful supply chain management (Lambert, Cooper, & Pagh, 1998). However, a more integrated supply chain also means that a company depends more heavily on its suppliers, which is not always preferably, as the recent Covid-19 outbreak has shown. If a company fully relies on suppliers in a specific geographical area, an unforeseen situation, such as a virus outbreak, natural disaster, or economic recession in that area could heavily disrupt a supply chain.

Design requirements

The final concept is partly developed on the basis of the design requirements, described in chapter "10 Design requirements". These requirements were also used to evaluate the final design. It is debatable to what extent the formulation of the design requirements impacted the final outcome. Probably, more broadly or more specifically formulated design requirements could have led to other results.

Limitations

Three limitations to this project can be mentioned.

First, the validity and reliability of the quantitative data gathered in chapter "7 Supplier research" is questionable. As it turns out, suppliers use different metrics to measure environmental sustainability, making it impossible to calculate environmental impacts within the scope of this thesis. More concrete insights in these environmental impacts could lead to more tangible and direct solutions to decrease environmental impact.

Second, the scope of this project was probably defined too broadly. The complexity of the fashion industry and the supply chain, the complexity and technicalities of textile wet processing and the limited possibilities to define environmental impact hampered the development of concrete and tangible environmental solutions. Even though this is something that could have been clear at the start of the graduation project, this was mostly discovered during the discover phase. Nevertheless, a feasible, viable and desirable collaboration strategy is delivered.

Lastly, the validation of the final strategy could not be done properly because during the last phase of writing this thesis, due to the outbreak of the Covid-19 virus, the office was closed. This made it harder to communicate with various stakeholders within MD.

14|3 Recommendations

Recommendations from three perspectives are proposed. First, recommendations to MD are described. Second, scientific recommendations for further research are proposed. Last, recommendations for interfaculty research are described.

Recommendations for MD

Six recommendations are proposed.

This thesis contributes to decreasing the significant environmental impacts of textile wet processing. However, besides textile wet processing, the consumer phase also has a significant environmental impact, mostly due to the release of microfibers to the water while washing clothes and due to the fact that a lot of textile eventually becomes waste. Therefore, two recommendations to further tackle sustainability issues are proposed to MD. First, it would be useful to impact the consumer phase by raising awareness on (environmental) sustainability issues with consumers. Second, MD could consider providing laundry bags to consumers that prevent the release of microfibers to the water by filtering.

Second, since digital printing is significantly less harmful to the environment than screen printing, MD could commit to use more digital printing. However, it should be taken in consideration that digital printing is more expensive and that digital printing provides a different quality than screen printing.

Third, since many tier 2 suppliers use the Global Recycled Standard, it is recommended to investigate the possibilities of using recycled fabric in MD's products. This is also already mentioned in MD's sustainability strategy.

Fourth, as described in the implementation plan in chapter "13 Roadmap & implementation plan", it is important to thoroughly analyse the environmental impact of MD's products. Since this is such a complex problem, it is recommended to execute this in collaboration with an organisation that has the expertise needed.

Fifth, it could be valuable to include project assurance in the implementation of the network. This should be a person or an organisation that oversees the project independently and objectively. The local organisation that is mentioned during implementation could take this role, but it would be valuable to include a project assurance that has no other interests in the project than objectivity.

Lastly, to execute this project, MD could considering to apply for funding via the "Fonds Verantwoord Ondernemen". This is a fund, supported by the Dutch government, to help companies execute such sustainability projects. Receiving a fund would increase the chances of success, since MD, and probably also suppliers, would need to invest less.

Recommendations for further research

From a scientific point of view, three recommendations for further research can be formulated.

First, it is clear that garment supply chains are complex and there is a worldwide lack of transparency and traceability. All fashion companies face similar challenges regarding transparency, since all supply chains are highly decentralised and shattered. Further research to better map the garment supply chain would be valuable.

Second, besides the fact that the supply chain is complex, the garment production process is incredibly complex, and the textile wet processes in particular. Measuring the environmental impact of one piece of clothing is very difficult. Organisations that offer tools to measure impacts in the supply chain, often require high membership fees to companies wanting to use those tools. It would be valuable to research how environmental impacts could be measured by companies that do not have the resources to affiliate with such organisations.

Third, further research on social sustainability would be valuable. As opposed to environmental sustainability, social sustainability is mainly qualitative and should therefore be measured and managed differently. It would be valuable to further research ways to manage social sustainability, preferably in close collaboration with stakeholders, e.g. factory workers.

Recommendations for interfaculty research

As mentioned, this thesis contributes to interfaculty research between the faculty of Industrial Design Engineering and the faculty of Technology, Policy and Management. Interfaculty research can be valuable, because it provides a more holistic view to a problem. I do believe that the solution that was presented in this thesis would probably not have emerged if the project was executed at one faculty. Both IDE and TPM brought their own points of view, methods and considerations to the table. In the future, I would suggest that with every research, the researchers ask themselves whether an interfaculty research could be valuable.

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15 Reflection

This chapter provides a reflection on this project from two perspectives. First, a reflection is written from an academic point of view that discusses the execution of this project. Then, this thesis is concluded with a personal reflection, where I reflect on the personal goals set at the beginning of this project.



15|1 Academic reflection

Contribution to this thesis

Many different stakeholders contributed to this thesis in various ways. As visualised in figure 43, many different stakeholders in the supply chain were involved when writing this thesis. A chemical supplier was interviewed, providing valuable input in chapter "8 Industry expert interviews". Four tier 2 suppliers provided valuable insight in textile wet processing during factory visits in China. Furthermore, seven tier 2 suppliers provided additional insights in the survey, both described in chapter "7 Supplier research". Lastly, different employees of MD provided insights in different topics, mostly during the brainstorm, as described in chapter "11 Ideation & conceptualisation". However, MD employees also contributed to all other chapters by providing input, validating results and giving feedback.

For a broader sustainability research, it would be valuable to include other stakeholders as well. For the purpose of writing this thesis, quite a lot of stakeholders already provided input. When starting to write this thesis, I was concerned whether I would be able to gather the knowledge at the suppliers, due to the cultural and language barriers and great distance. The fact that so

many suppliers were willing to show their factories or provide input in surveys and interviews has positively surprised me and has been very valuable to this thesis and its end result.

Stakeholder dynamics

As described in paragraph "5/2 Stakeholder analyses", the outcome of this project hopefully contributes to a change in stakeholder dynamics. It was stated that this project should increase the interest of tier 2 suppliers and should ensure that MD can positively influence tier 2 suppliers. Since the final strategy is not implemented yet, it is too early to conclude whether this will happen. Developing a network of suppliers would in all probability contribute to reaching these goals, but is important to evaluate on this.

Prioritising sustainability

During this project, among other things, I learned a lot about sustainability in the fashion industry. I found out that the fashion industry is one of the most polluting industries and that fashion companies are trying to tackle this challenge. However, even though many companies state that sustainability is a priority, the outbreak of the Covid-19 virus has shown that this might not always be the case.

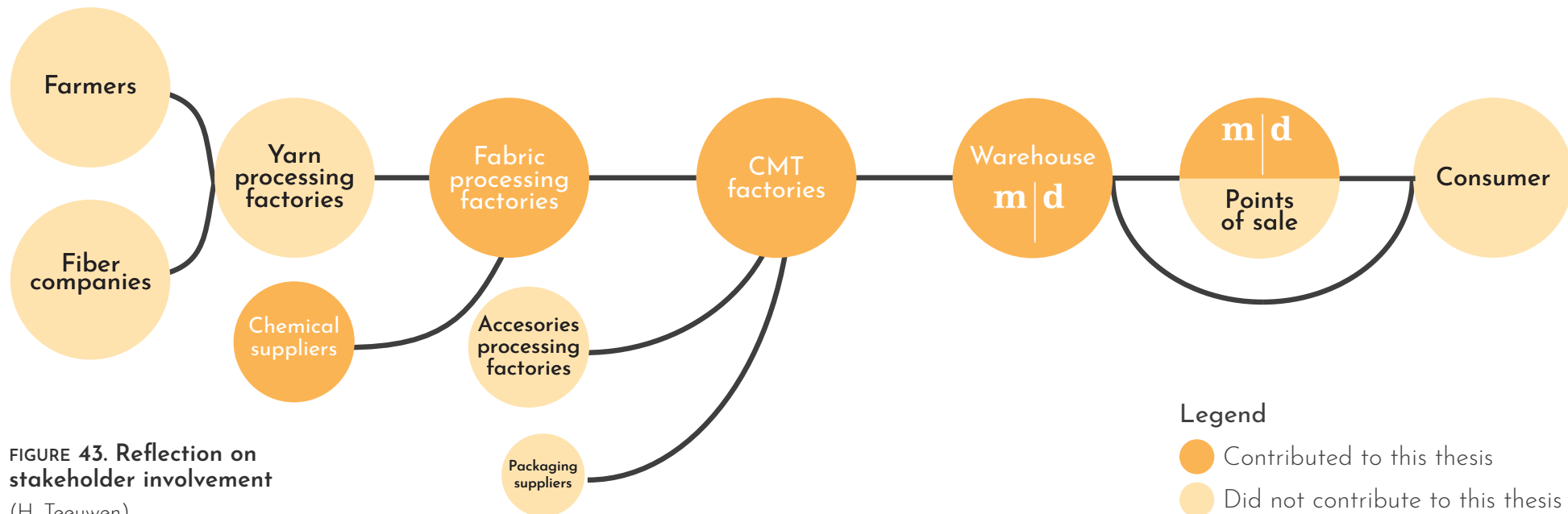


FIGURE 43. Reflection on stakeholder involvement
(H. Teeuwen)

Due to the pandemic, large fashion companies are in dire straits. Stores are closed and turnovers are declining. As a result of this sinking demand for apparel, brands and retailers are cancelling or postponing orders and refusing to pay for clothing their suppliers have already produced, invoking force majeure (Anner, 2020). However, these suppliers already made the cost of purchasing fabrics and producing these orders. This has led Asian suppliers to fire many factory employees; in Bangladesh alone, since the outbreak of the virus more than one million employees in fashion factories have been fired or furloughed (Anner, 2020; Elferink, 2020). Power relations in garment supply chains have led to contractual terms that benefit the brands and retailers in times of crisis. Asian suppliers carry the risks; the terms of payment start after apparel is shipped and even then, brands could still cancel orders and refuse to pay them. However, these suppliers seem to have no choice. If they do not agree with these terms, another supplier will (Elferink, 2020). Simply put, suppliers are too dependent on these brands to have any power.

Currently, millions of factory workers have been fired or do not get paid and are struggling to pay rent. Large brands and retailers are destroying a whole supply chain, that they will again need in the future. Even though this does not apply to MD, it shows that garment supply chains still have a lopsided balance of power and that there is a long way to go for the fashion industry to truly be sustainable.

15|2 Personal reflection

At the beginning of the project, in the project brief (appendix 1), I stated four personal goals to hold onto during the execution of this project. In this paragraph, I will reflect on these goals.

Balance keeping the overview with going in detail

MD's supply chain is quite complex; there are many suppliers and many processes needed to produce its products. Currently, MD has little grip on the processes of its suppliers and the sustainability of its supply chain. This leads to two possible problems. On the one hand, it would be a risk to lose myself in the details of the processes too much. In the limited time available, it is simply not possible to sift out all details in all production processes. On the other hand, there is a risk that the project will be too general. I could spend all my time scratching the surface, without going in depth. This way, I would not be able to actually decrease impact in MD's supply chain. During my graduation project, I would like to be able to balance "keeping the overview" and "execute

in-depth research" to achieve the maximum result possible.

During the execution of this project, this is a challenge that I faced many times. Even though I quickly decided to focus on textile wet processing, I still have found myself lost in details. During the process, I was always working parallel on multiple chapters and struggled to digest the wide range of information that was available into meaningful content for this thesis. This has learned me a lot and I am proud to say that I managed to achieve this in my final thesis. It has become a coherent story that shows a detailed but complete overview of sustainability in the fashion industry.

Execute research in uncomfortable environments

During my studies I have already been abroad a few times. I have done my minor project in Ghana, a voluntary project in Morocco and an internship in Indonesia. For this project I will be going to China to interview and observe processing factories in the supply chain of MD. I would like to achieve the results needed in spite of the cultural barrier and limited time in China. Also, I am very interested to experience how such factories produce its products and to see this up close.

Even though I have experience living and working abroad, interviewing suppliers in China was an interesting challenge. With some suppliers, there was a huge language barrier and all the interviewing had to go through the tier 1 supplier, who helped us translating. Also, I experienced an interesting cultural barrier. Even though I had prepared the interview and was asking all questions, some suppliers seem to only have attention for the head of product and design, who joined me on the factory visits. She is a manager and I was "just an intern", which made it harder for me to ask my questions.

Nevertheless, the interviews and factory visits have been incredibly valuable, to the results of this thesis but also for my own understanding of the complexity of the production process. With a different planning however, I could have had more time to prepare and may have been able to include suppliers in the development of the final concept, which could have increased the desirability of the final concept.

Planning and project management

This is the first time that I am executing such a big project by myself. Because I have a chair on IDE, a mentor on TPM and two mentors from the company, I want to focus on project management and communication. I want to

make sure that all agreements are clear to everyone at all times, so that my graduation project will go smoothly. Also, because I believe 20 weeks is a relatively short time, I want to focus on planning to get the most out of it.

This has been a more complex goal than I would have thought in the beginning. In the beginning of the process, I found it hard to own the project and take responsibility for it. When the direction of the thesis was not yet clearly defined, I struggled with doing so and hence struggled to take ownership over the project. I tend to over-analyse things before daring to take decisions. However, my supervisory team has really helped me to recognise that I was able to take decisions after some analysis. During the project, I have improved my project management skills. In the beginning I was quite stressed about my graduation project and I was insecure about my project. This led to less effective meetings and probably less prepared meetings. Over time, I opened myself more to the helpful feedback of my supervisors, which led to the fact that meetings were better prepared, communication was more useful and all meetings were more valuable.

Regarding planning, I have mixed feelings. On the one hand, I managed to deliver this thesis, analysing and describing a coherent overview of sustainability in the fashion industry. I am proud at myself that I have been able to turn this mess of information into a comprehensible and valuable story. On the other hand, I have had some planning issues. My plannings sometimes was a little too tight, which led to delays when unforeseen incidents occurred. Even though it felt that I was just unlucky that these incidents happened at the last minute, I recognise that I should not plan to be finished in the last minute. This is something that happened mostly at the beginning of this project and I can say that I have learned from my mistakes. I am writing the last pieces of my thesis with much time to spare, which is a very relaxed feeling.

Delivering a visual and implementable strategy to a company

With this project, I want to bring my strategic skills, developed during my SPD master, in practice. At the end of my graduation internship, I want to deliver a strategy that provides a smooth implementation plan for MD to improve the sustainability of its supply chain.

My last goal was to bring my SPD skills in practice. By delivering a collaboration model, a roadmap with a sustainability strategy and an implementation plan, I would say that I have successfully reached this goal.

Even though collaborations between suppliers in a supply chain is not something that my SPD master programme focuses on, it was interesting to experience how skills obtained during the master could still be brought into practice with this subject.

Final notes

Over the last months, I have been analysing the fashion industry to write my thesis. With this end result, I deliver a collaboration model to MD that I believe can be very useful to improve sustainability in the supply chain.

I was, and still am, shocked by the environmental impacts of the fashion supply chain and the unawareness of consumers. Also the fact that fashion supply chains are so shattered, production processes are so complex and everyone measures everything so differently has shocked me.

Even though a lot of companies are trying to make a difference there is still a long way to go. I genuinely hope that all brands and retailers, but also consumers, take their responsibility in tackling these problems.

RESOURCES

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