MIT Sloan School of Management
Strategies for Sustainable Business
Final Report – Recycled Cotton for Gap Inc.
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Introduction and Problem Statement

Gap Inc. is a Fortune 500 clothing retailer that sells a range of products under the Gap, Banana Republic, Old Navy, Athleta, and Intermix brand names.[1] Gap Inc.'s net sales in 2015 were approximately $15.8bn, and they ended the year with approximately 141,000 employees.[2] Additional information about the textile industry as it relates to recycled cotton can be found in Appendix A.

Gap Inc. engaged MIT with the goal of evaluating the potential for the incorporation of recycled cotton into their clothing, with a specific focus on the potential supply of recycled materials and the best available recycling technologies. Presently, recycled cotton presents challenges due to concerns around its cost, quality, and availability. However, Gap Inc. is interested in understanding the potential opportunities for utilizing recycled cotton due to its perceived decreased environmental impact in relation to virgin cotton.

The remainder of this report will detail the motivation for the use of recycled cotton within the retail industry, work done by the student team to scope the project, the current manufacturing processes employed by Gap Inc., the current and future technologies for recycling cotton, and the challenges to implementation.

Project Motivation

Cotton's Environmental Impact: Two of the major motivations for this project are the environmental and the social impacts of cotton growing and clothing manufacturing. For the purpose of this work, the team has focused on the environmental impacts, since the recycling of cotton has the potential to directly reduce those impacts.

Two of the environmental impacts that are of concern to Gap Inc., and to the industry as a whole, as they relate to cotton growing and manufacturing are water use and energy use. A majority of the impacts of cotton production as they relate to water use occur in the agricultural and consumer use phases. The impacts of energy use are significant in the use phase, but are also high in manufacturing as well.[3] Therefore, the environmental benefits of using recycled cotton in place of virgin cotton would depend heavily on two key factors. The first would be the total energy used in the recycling of the textiles. If the energy required in the recycling process was higher than the energy used in the standard manufacturing process, then the marginal benefits of using recycled cotton may be small from the perspective of reducing overall energy

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[1] Gap Inc. Global Sustainability Report 2013-2014: Our Futures are Woven Together. Published in January 2016. Web. <http://www.gapincsustainability.com/sites/default/files/Gap%20Inc.%202013%20-%2014%20Report.pdf>.

[2] Gap Inc. 2015 Annual Report. Published in 2016. Web. <http://investors.gapinc.com/phoenix.zhtml?c=111302&p=irol-sec>.

[3] Muthu, S. S., Chapter 9, *Handbook of Life Cycle Assessment (LCA) of textiles and clothing*. Cambridge, UK : Woodhouse Publishing, [2015]: 2015.

use. Second, it will be important for recycled fibers to reduce the need for virgin materials, thereby reducing the overall impacts from the agricultural phase. This could potentially allow Gap Inc. to continue its growth in term of total sales while also reducing the impacts caused by water usage during the farming of cotton. In addition to these two points, the reduction of waste sent to landfills and incinerators would also carry with it a reduction in negative environmental impacts.[4]

Although there is limited research on the environmental impacts of recycled cotton, several researchers have quantified the life cycle impacts of conventional cotton textiles, providing a benchmark against which to compare recycled clothing. The Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing (herein referred to as "The Handbook") provides details and insights into the environmental impacts of cotton, as well as the potential for recycling. Additionally, several studies in the past have calculated the impacts of cotton in various forms, and where in the life cycle each impact is the most significant.[5] [6] [7] [8] [9] [10] [11]

Potential End-of-Life Scenarios for Cotton: Building on the discussion of cotton's environmental impacts, it is important to consider the end-of-life stage when calculating the environmental impact of cotton textiles. According to The Handbook, there are five overall potential options for reducing the impact of end-of-life textiles. The five options are listed below, in order of most to least effective with regard to reducing the impact of textiles.[12]

1. Waste prevention through the use of fewer materials
2. Product reuse
3. Material recycling
4. Energy recovery through incineration
5. Landfilling or incineration without energy recovery

Due to this, any closed loop recycling scheme, where clothes are collected in store, would need to also focus on reuse. This is because reuse not only reduces the mass of textiles that enter

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[4] Muthu, S. S., Chapter 6, *Handbook of Life Cycle Assessment (LCA) of textiles and clothing*. Cambridge, UK : Woodhouse Publishing, [2015]: 2015.

[5] Life Cycle Assessment of Cotton Fiber & Fabric Full Report – Prepared for Vision 21 A Project of the Cotton Foundation. Cotton Incorporated. Published in 2012. Web. <http://cottontoday.cottoninc.com/wp-content/uploads/2014/07/LCA_Full_Report.pdf>.

[6] The Life Cycle of a Jean – Understanding the Environmental Impact of a Pair of Levi's 501 Jeans. Levi Strauss & Co. Published in 2015. Web. <http://levistrauss.com/wp-content/uploads/2015/03/Full-LCA-Results-Deck-FINAL.pdf>.

[7] Sandin, G.; Peters, G. M.; Svanström, M., Moving down the cause-effect chain of water and land use impacts: An LCA case study of textile fibres. *Resources, Conservation & Recycling* **2013,** *73*, 104-113.

[8] Muthu, S. S.; Li, Y.; Hu, J.-Y.; Mok, P.-Y., Recyclability Potential Index (RPI): The concept and quantification of RPI for textile fibres. *Ecological Indicators* **2012,** *18*, 58-62.

[9] Muthu, S. S.; Li, Y.; Hu, J. Y.; Mok, P. Y., Quantification of environmental impact and ecological sustainability for textile fibres. *Ecological Indicators* **2012,** *13*, 66-74.

[10] Allwood, J. M.; Laursen, S. E.; Russell, S. N.; de Rodríguez, C. M.; Bocken, N. M. P., An approach to scenario analysis of the sustainability of an industrial sector applied to clothing and textiles in the UK. *Journal of Cleaner Production* **2008,** *16*, 1234-1246.

[11] Woolridge, A. C.; Ward, G. D.; Phillips, P. S.; Collins, M.; Gandy, S., Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin material: An UK energy saving perspective. *Resources, Conservation & Recycling* **2006,** *46*, 94-103.

[12] Muthu, S. S., Chapter 16, *Handbook of Life Cycle Assessment (LCA) of textiles and clothing*. Cambridge, UK : Woodhouse Publishing, [2015]: 2015.

the end-of-life phase, but also leads to a used garment potentially taking the place of newly manufactured garment. Woolridge et al. estimated an energy savings of 65 kWh when reused textiles displace a kilogram of virgin cotton, but this value is highly uncertain, and will vary based on the types of products under consideration and the logistical requirements of returning the product to market.[13]

Moving down the list of potential end-of-life options to recycling, clothing retailer Esprit carried out its own study, finding that the use of recycled cotton in place of virgin cotton allowed for a water savings of up to 75%. However, the methodology used to arrive at this number is unclear, and it doesn't appear to account for the use phase.[14] In addition, another clothing company, Playback, completed an LCA on sweatshirts that were made using recycled cotton and polyester. While there is no mention of the quality of the resulting product, from an environmental perspective, it outperformed a conventional sweatshirt with regard to waste, fossil fuels used, global warming potential, air pollution, land used, and carcinogens.[15]

Overall, material recycling holds the potential to lower the negative environmental impacts of cotton textiles. However, a long term strategy must also focus on two key areas in addition to recycling: 1) changes in the design of clothing that reduce material and chemical use, and 2) the capacity of retail companies to incorporate a closed loop, post consumer collection system.

Scoping the Project

A key part of this work was the team's effort to focus the scope of the project in order to provide analyses and recommendations that Gap Inc. could carry forward as it determines the most appropriate uses of recycled cotton in its products. The first step in this process was to identify the high level topics that relate to a potential business case for recycled cotton use. The team used the framework presented in the "Laboratory for Sustainable Business" class, which was centered on risk, revenue and cost. Analyzing the business impact of recycled cotton through the lens of these three business factors helped the team to structure the problem in a systematic manner. The limitation of this tool is that it does not provide an in depth framework around specific implementation plans and options for an organization. However, due to the fact that the goal of this work was to identify the key first steps that Gap Inc. can take with regard to recycled cotton, it worked as an effective scoping and framing tool.

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[13] Muthu, S. S., Chapter 6, *Handbook of Life Cycle Assessment (LCA) of textiles and clothing*. Cambridge, UK : Woodhouse Publishing, [2015]: 2015.

[14] Esprit Sustainability in Practice. N.D. Web. Accessed April 2016. <http://www.esprit.com/company/sustainability/sustainability_in_practice/>.

[15] GreenerDesign Staff. Playback Clothing Shows Benefits of Recycled Cotton, Bottles with Lifecycle Analysis. Greenbiz. June 11, 2009. Web. Accessed April 2016. <https://www.greenbiz.com/news/2009/06/11/playback-clothing-shows-benefits-recycled-cotton-bottles-lifecycle-analysis>.

Table 1. Potential Sources of Risks, Revenues, and Costs Associated With the Use of Recycled Cotton (Framework Adapted from Laboratory for Sustainable Business Class)

Risk	Revenue	Cost
Lack of visibility into supply chain	Willingness to pay of consumers for recycled products	Cost of collecting offcuts
Variable supply of offcuts	Access to a new customer base that did not buy from Gap Inc., but would be attracted now considering the sustainability aspect	Additional cost of recycling process
Environmental impacts of products	Spillover effects into other product lines of Gap Inc.	Increased labor costs

The work done by the team to scope this project addressed two of its key challenges, the complexity of incorporating a new material (in this case recycled cotton) into a company's supply chain and the fact that there are limited examples of companies that are taking on this challenge successfully. Therefore, the team first examined all possible project methodologies, including a life cycle analysis, a material flow assessment, a positioning study, and a logistics study centered on the reverse supply chain challenges inherent in a closed loop recycling process.

In order to assess the usefulness of these methodologies for Gap Inc., the project team conducted a series of meetings and interviews with Gap Inc. employees and external stakeholders, including staff for Global Sustainability and Global Supply Chain. The team also interviewed factory managers in Jakarta and Hong Kong and an industry expert. These interviews gave the team important insights into Gap Inc.'s current supply chain and manufacturing processes, as well as the current state of the textile industry as it relates to recycled cotton. These interviews were valuable because they allowed the team to narrow the scope of the project to address the key concerns of Gap Inc., namely, what their first steps should be related to recycled cotton, and the strategies that they need to consider now for a successful long term implementation of recycled cotton. Therefore, the team focused on the positioning study, and providing Gap Inc. with the information that it would need to make decisions about recycled cotton on an appropriate time scale.

Based on an analysis of the risk, revenue, cost framework, the team identified two key areas to focus on, the supply of offcuts and the cost of using recycled cotton. Working closely with Gap Inc., the team focused the scope down to a narrow set of products that are central to Gap Inc.'s business. Additionally, two manufacturing processes were considered, the cut/sew vendors, where offcuts would be sourced, and the fabric mills, where recycled cotton would re-enter the supply chain. Each of these steps is detailed in the sections that follow. Deliverables will also include an analysis of best practices in chemical and mechanical recycling.

Gap Inc.'s Supply Chain and Manufacturing Process

A key challenge for Gap Inc. with respect to recycled cotton is the makeup of its supply chain and manufacturing processes, which are detailed here. The main challenge is the fact that Gap

Inc. does not own the clothing until it is complete. The manufacturing process presented here is generalized, and represents not only Gap Inc., but other retailers as well.

Once the cotton is picked, it is transported to a spinner, which converts the cotton into cotton yarn. From there, the cotton yarn is transported to a mill, which spins the threads, produces the fabric, and dyes and finishes the final product. From there, the dyed fabric is transported to a cut/sew vendor that manufactures the final product that will end up on store shelves. A diagram of this process can be found in Figure 1. Within this supply chain, Gap Inc. does not take ownership of the products until they are complete and shipped to their distribution centers. Therefore, Gap Inc. can only exert a secondary influence over the processes that occur at each of these steps. To date, Gap Inc. has engaged with the cut/sew vendors and mills through various sustainability programs, but has yet to propose projects focused on recycled cotton.

Waste is generated at each of these steps along the supply chain, including wastage as lint and fiber at the mills, and as offcuts at the cut/sew vendors. This project will focus on offcuts, which are the cotton scraps that are left over after the various shapes and patterns are cut during the garment manufacturing process. These offcuts have the same material composition and dying as the final product, and provide a potential supply of recycled cotton. However, in most of the cut/sew vendors that supply to Gap Inc., these materials are discarded as waste. The following section will provide an overview of the team's work, which has not been included in its entirety for confidentiality reasons.

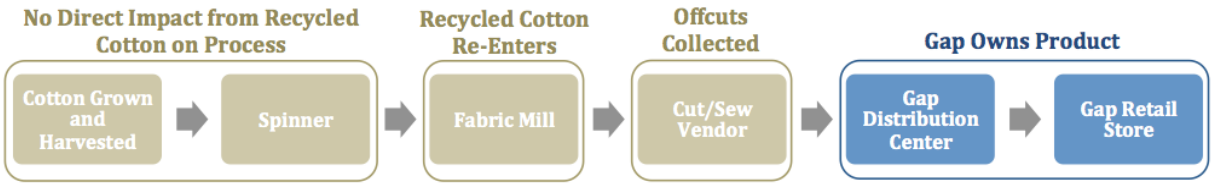

Figure 1. Generalized Schematic of Gap Inc.'s Supply Chain

Supply of Cotton Offcuts

As previously described, one of the key risks to Gap Inc. with respect to recycled cotton is the available supply. The team collected data on the amount of fabric required to manufacture a single pair of jeans and a cotton t-shirt, accounting for waste in two forms. The first was the "extra" fabric that was deliberately included in the manufacturing process to ensure that there was never a shortage of available material. The second was the waste generated by defects or manufacturing errors. It is important to consider each of the types of waste separately from the perspective of available supply because the "extra" fabric includes only the fabric itself that has been cut away and discarded, while the defective clothing may also contain additional parts such as buttons and zippers that will need to be removed. Each of these types of offcuts are generated at the cut/sew vendor stage.

Cost Impacts of Recycling Cotton

As Gap Inc. is only a buyer of finished products from vendors, the incremental costs due to the addition of recycling cotton will have to be borne by the vendors. However, as their unit cost of production increases, a portion of this will get transferred to Gap Inc. during procurement.

Figure 2 shows a potential future workflow of how recycled cotton could be integrated into Gap Inc.'s vendors' existing production process.

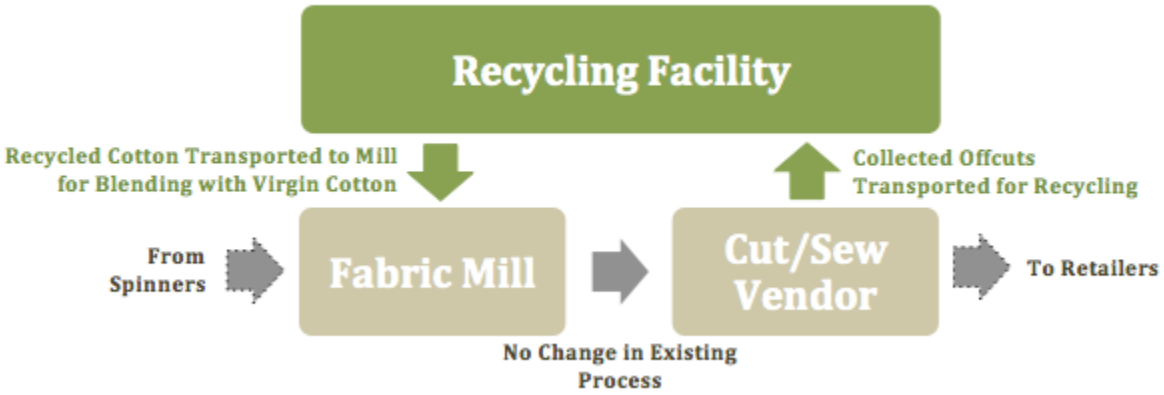

Figure 2. Generalized Schematic of Recycling Operations Within Existing Manufacturing Process

As offcuts are collected at the cut/sew vendor stage, they need to be transported to the recycling plant. The recycling plant will produce recycled cotton that will be sent to stage 3 to be blended into virgin cotton again. The next section will describe in detail the two overall types of cotton recycling, mechanical and chemical. This additional operation could have the below increases in cost, however, these would need to be quantified according to the existing cost structure of the organization:

- Cost of collecting offcuts
- Recycling/processing costs
- Transportation
- Labor

If Gap Inc. does decide to move forward with the implementation of recycled cotton, knowing the supply risks and the costs, as well as the potential benefits from an environmental and a branding perspective, it will need to carefully consider the best available recycling technologies, and which would align most effectively with its current supply chain.

Cotton Recycling

There exist two main methods for repurposing cotton fabric back into yarn that can be used to thread new garments. The two methods are ***mechanical recycling and chemical recycling***. Any retailer hoping to incorporate recycled cotton into their clothing would need to decide which of these options fit within the organization's goals for cost, quality, scalability, and environmental impacts. These conditions could change based on the size of the organization, the key geographies where it operates, and the types of clothing it is manufacturing. Each of the processes are described in detail in order to help organizations make decisions about the tradeoffs between fiber quality and environmental performance. Additionally, each of these steps would need to be considered if the impact of the end-of-life stage of a garment was to be analyzed using a life cycle assessment.

Mechanical recycling: Mechanical recycling involves separating and re-spinning of fabric into yarn through mechanical action. First, the textiles are collected and put into bales. The bales are passed through a bale opener, which mechanically strips fibers from the fabric. The fibers are

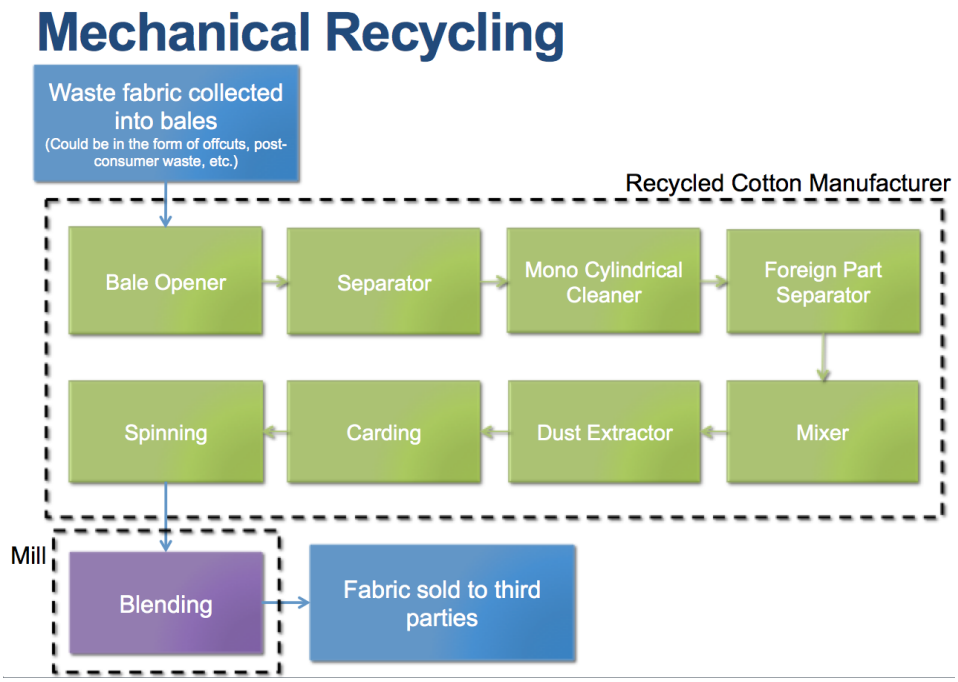

Figure 3. Overview of Mechanical Recycling Process

Chemical recycling: Chemical recycling involves the separation of cotton fibers through the use of chemical solvents. In the past, this process has been largely avoided given the high volume of water required for the process, as well as the toxicity of the chemicals used that renders the water ineligible for reuse.

However, recent research into new, environmentally friendly solvents for cotton recycling has made chemical recycling a more attractive process. Two novel methods were investigated in further detail:

The Lyocell Method: The Lyocell method is a novel chemical method for recycling a feed of 100% cotton. The Lyocell method uses N-methylmorpholine N-oxide or NMMO to dissolve cotton fibers.[22]

NMMO is reported to completely dissolve cotton fibers from input. Cotton fabrics are manually cut into 10 x 10 mm pieces and passed through a beater deconstruction process in which the fabric is passed between a beater roll and a beater plate with standard weight of 4.5 kg. 360 g of fabric pieces are mixed in 23 L of water to help in the deconstruction and the process is performed for 90 minutes until a pulp of consistency of 1.56% s/w is obtained. After beating, the pulp is collected, drained, and air dried.

Viscose fibers are mixed in a 1:10 ratio with 50% w/w solution of NMMO and 0.2 g n-propyl gallate. The mixture is subjected to increasing temperatures and reduced pressure in a vacuum in order to create a dehydrated slurry known as 'dope'. Once the composition of the dope reached a concentration of 9% cellulose, 13% water and 78% NMMO, fibers are ready for spinning. The dope is passed through a 100 um spinneret, spun and stretched at 115°C. Air gap

[22] Haule, L.v., C.m. Carr, and M. Rigout. "Preparation and Physical Properties of Regenerated Cellulose Fibres from Cotton Waste Garments." *Journal of Cleaner Production* 112 (2016): 4445-451. *Elsevier*. Web. 31 Mar. 2016.

conditions were in the form of 30 mm holes at 24°C, 53% relative humidity. The winding is speed of 25.1 m/min. Fibers are then precipitated using a polar liquid in which the cellulose is not soluble. This liquid is usually plain water. After precipitation, the fibers are oven dried at 60°C overnight. The fibers are now ready for blending with pulp from paper and wood containing high amounts of cellulose.

This method was further tested with fabrics containing 'Easy care,' the fabric finisher. Easy care was found to reduce cotton solubility in NMMO.[23] Thus, testing was done to remove Easy care prior to the Lyocell process. To remove Easy care, fabrics were washed in acid-alkali solution prior to the Lyocell process.[24]

The Lyocell method is considered environmentally benign: NMMO is non-toxic in the event of a spill and is able to use other cellulosic waste such as paper and wood pulp from processes outside the fashion industry.[25] Moreover, because of the lack of mechanical strain on the fibers, it results in fabrics of attractive mechanical and comfort properties: In their experiment, Haule et al. perform the recycling on fabrics that had been washed 100 times, and see no tensile strength deterioration. This is due to the fact that because the new fibers are mixed with wood pulp, the resulting fiber is of higher molecular weight and therefore higher tensile strength. The main concern with this process are the volume of water used, the energy intensiveness given the high temperatures required, and the potential toxicity in removing Easy Care from fabrics.

Companies that currently implement the Lyocell method are Re:newcell in Sweden, and presumably EvRnu in Seattle, WA. – NOTE: Given the proprietary nature of EvRnu's process, we were unable to confirm their use of the Lyocell process, but based on the description of their process strongly, we strongly infer that this is the case.

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[23] Haule, L.v., C.m. Carr, and M. Rigout. "Preparation and Physical Properties of Regenerated Cellulose Fibres from Cotton Waste Garments." *Journal of Cleaner Production* 112 (2016): 4445-451. *Elsevier*. Web. 31 Mar. 2016.

[24] Haule, L. V., C. M. Carr, and M. Rigout. "Investigation into the Removal of an Easy-care Crosslinking Agent from Cotton and the Subsequent Regeneration of Lyocell-type Fibres." *Cellulose* 21.3 (2014): 2147-156. Web.

[25] Haule, L.v., C.m. Carr, and M. Rigout. "Preparation and Physical Properties of Regenerated Cellulose Fibres from Cotton Waste Garments." *Journal of Cleaner Production* 112 (2016): 4445-451. *Elsevier*. Web. 31 Mar. 2016.

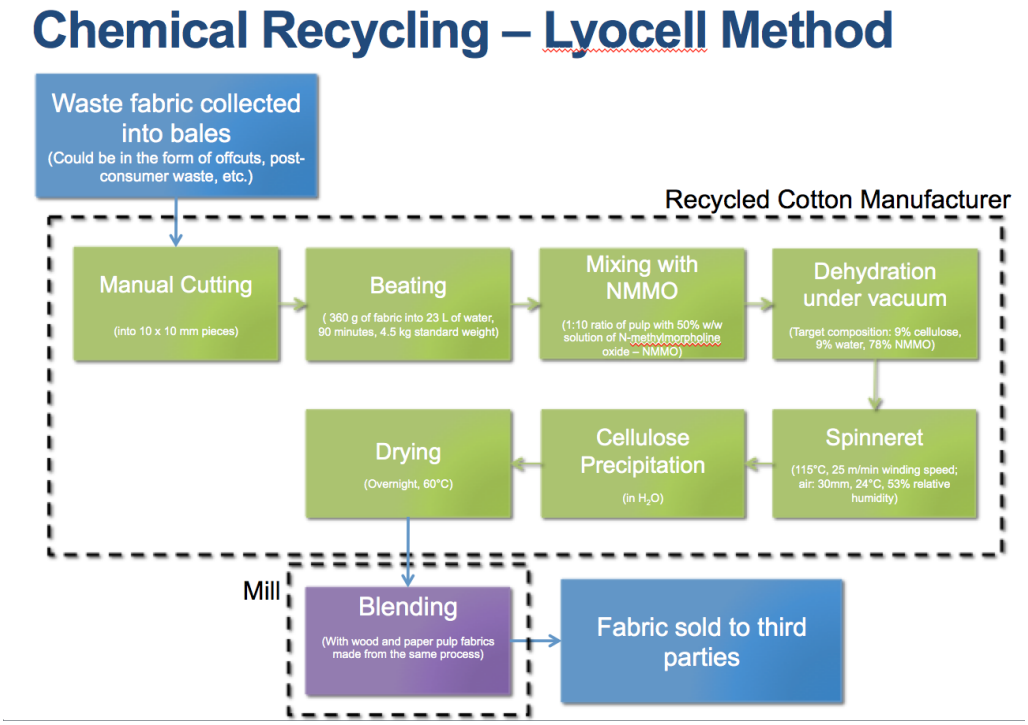

Figure 4. Overview of Lyocell Recycling Process

AMIMCI: The AMIMCI method uses 1 allyl-3-methylimidazolium chloride (AMIMCI) to separate cotton fibers from cotton-polyester blend fabrics.[26]

The polyester/cotton fabrics are dried at 105°C for 24 hours to remove all moisture within the fabric. Fabrics were submerged in AMIMCI at 80°C for 6 hours. AMIMCI selectively dissolves cotton and not polyester, so after 6 hours the undissolved component (polyester) is removed, rinsed, and weighed. The cotton fibers are recovered by funneling. Then an ionic liquid, usually plain water, is used to precipitate the dissolved cotton fiber. The cotton dissolution is reported to occur fastest at 120°C.

This process is also considered to be environmentally benign. The solvents employed are non-toxic to the environment in the event of a spill and cotton is regenerated using water. Moreover, no difference was found between tensile properties between virgin cotton and the regenerated cotton.

This process is considered advantageous because it can intake any material combination in the textile feed. However, it has similar concerns as the Lyocell process: it uses a high volume of water and the energy intensiveness of the process to achieve high temperatures requires further exploration.

[26] Silva, Rasike De, Xungai Wang, and Nolene Byrne. "Recycling Textiles: The Use of Ionic Liquids in the Separation of Cotton Polyester Blends." *RSC Advances RSC Adv.* 4.55 (2014): 29094. Web. 31 Mar. 2016.

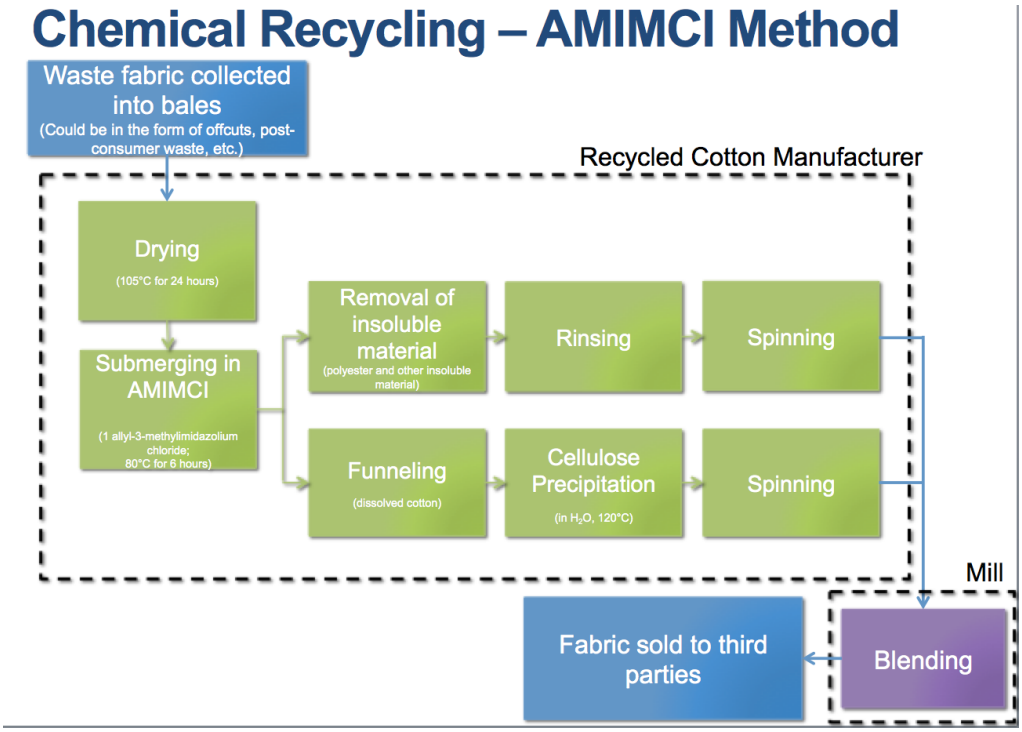

Figure 5. Overview of AMIMCI Recycling Process

Where Recycled Cotton Re-Enters Manufacturing

Regardless of the recycling method used among the methods previously discussed, recycled cotton would enter the production process in the form of a fully finished fabric for the garment manufacturer to use.

Given the current Gap Inc. production process, recycled cotton would enter the process in the form of Gap Inc. choosing fabrics from recycled cotton producers, and indicating their fabric specifications to the garment manufacturer at the time of commission (cut/sew vendor). Because the product comes in the form of a finished fabric, the process for the garment manufacturer would remain the same. Subsequently, Gap Inc. would come to own the finished recycled product, and the supply chain would remain virtually unchanged.

Some of the key considerations in choosing a source of recycled cotton are the content of the recycled yarn as well as the recycled amount in the final product. Current mechanical recycling methods do not make it possible for Gap Inc. to produce a 100% recycled cotton product, but rather a partially recycled product because of the loss in tensile strength of the yarn.

The Lyocell method, in theory, allows for the production of a 100% recycled product. However, while being 100% recycled, this product would *no longer be 100% cotton* given the introduction of cellulose from paper and wood pulp. This method, while providing a competitive advantage in producing a 100% recycled garment, would compromise the vision of 100% recycled cotton.

Finally, the AMIMCI process seems the most promising in producing a 100% recycled cotton garment, however this method is in early research stages and long from commercialization. The method was developed by the Institute for Frontier Materials in Deakin University in Australia.

While this method seems the most promising in terms of innovation, the innovation comes at the expense of timing. However, entering into partnership with this organization could create the opportunity for a recycling in plant in Australia, which is in proximity to Asia, and could generate positive network externalities.

Therefore, by introducing recycling, Gap Inc. is no longer gaining competitive advantage, but rather keeping up with the industry trend and avoiding damage to its reputation. *The choice that Gap Inc. needs to make is whether to focus on producing 100% recycled garments, in which case the Lyocell method is the recommended method of recycling, or whether to wait but potentially gain a competitive advantage by producing 100% recycled cotton through new novel methods such as the AMIMCI method.* The following decision tree could be used by Gap Inc. to assess which method of recycling will be the best fit within its supply chain.

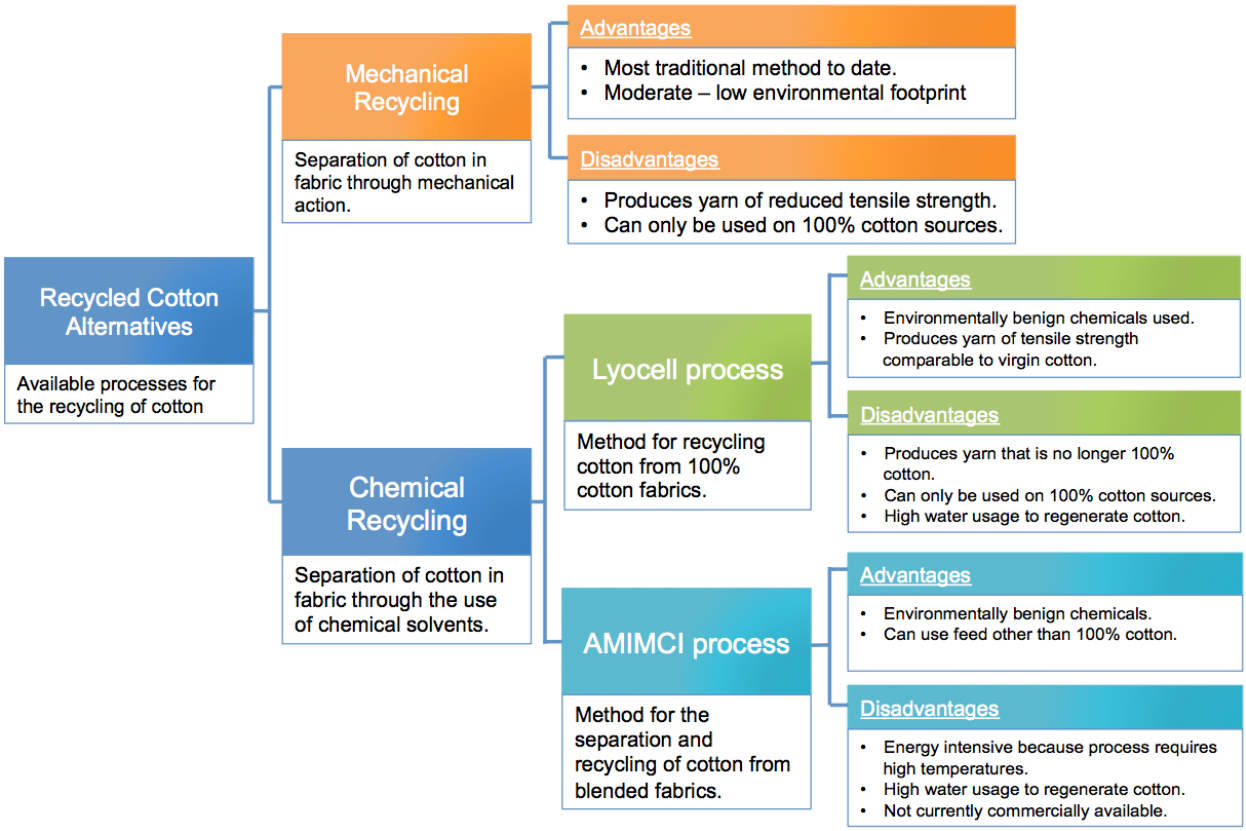

Figure 6. Decision Tree Showing the Major Options for Gap Inc. with Respect to Cotton Recycling

Market research shows that competitors, such as Esprit and H&M, have already incorporated recycling into their supply chains and offer recycled collections. H&M already uses the Lyocell method, in partnership with Re:newcell, to produce a fully recycled garment line. Given these circumstances, we recommend that Gap Inc. focus on building a partnership with a cotton recycling company, preferably with a manufacturing facility in Asia.

Challenges of Implementation

While the potential benefits from using recycled cotton are evident, there are several challenges that would accompany this venture for clothing retailers. These challenges include the following:

- Additional Logistical Requirements
- Strategic Relationships with Cut/Sew, Mill, and Recycling Vendors
- Consumer Behavior Towards Recycled Cotton

Additional Logistical Requirements: The inclusion of recycled cotton involves significant changes to certain parts of the supply chain currently operated by Gap Inc., depending on the processes employed. If using offcut material from cut/sew vendors, this material has to be collected and transported to a recycling facility. Then it must be taken to the mill stage and reinserted into the manufacturing process. These additional logistical challenges represent higher costs and added variability to the current supply chain of Gap Inc.

If Gap Inc. was to consider collecting post consumer apparel at their stores, then the logistical challenge is more complicated. This would require an analysis of a complete reverse supply chain. Gap Inc. would transport used garments from retail stores all the way back to recycling facilities. While this might add cost and complexity, it should be noted that the potential offset in using virgin cotton could provide a viable business case, not to mention the potential for reduced environmental impacts. To help in this analysis, the lessons learned from the Gap Inc. 2010 “Blue to Green” program would be helpful. During this program Gap Inc. offered to collect used denim from customers in order to convert it into UltraTouch Natural Cotton Insulation.[27] While only a short program, the logistics and cost related to implementing this collection program would be insightful.

Strategic Relationships with Cut/Sew, Mill, and Recycling Vendors: As Gap Inc. does not own the cut/sew vendors and mills, relationships with these vendors must be strong in order to implement these significant changes to current practices. Additionally, new relationships with recycling manufactures would have to be created.

Cut/Sew Vendors

At the cut/sew vendor, offcuts must be collected, sorted, and transported to local manufacturing facilities. To add to this complexity is the fact that the majority of cut/sew vendors produce garments for other competing companies. Additionally, according to a Supplier Sustainability Manager with Gap Inc. in Jakarta, some vendors currently have other organizations informally collecting this offcut waste. As such, Gap Inc. would need to work hand in hand with each vendor to recognize how to collect offcuts, deal with the mixing of competing brand material, and potentially contract with the organizations that currently collect offcut waste in some facilities. Gap Inc. would also need to quantify the total mass of offcuts that are currently being collected and if this material would be available for recycling. Presently, Gap Inc. and other retailers are shifting away from “policing” to capacity building at its suppliers, which may aid this transition.

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[27] “Cotton Incorporated Partners With Gap For Nationwide "COTTON. FROM BLUE TO GREEN.®" DENIM DRIVE.” *Cotton Incorporated.* N.p., n.d. Web. 25 Apr. 2016. <http://www.cottoninc.com/corporate/Pressroom/PressReleases/2010/Gap-Denim-Recycle-Program.cfm>.

Mill Vendors
At the mill level, blending in recycled cotton presents a change from established practices depending on the ratio of recycled to virgin cotton and other textiles. Again, Gap Inc. would need to strategically partner with these mills to ensure that proper training, procedures, and quality assurance are maintained when adding in recycled cotton.

Recycling Vendors
The need to physically recycle the cotton, whether mechanically or chemically, requires that new relationships be formed with recycling vendors which inhibit high quality standards and have the ability to scale to meet Gap Inc.'s large market base. In order to help with this challenge, working with the Sustainable Apparel Coalition or local Gap Inc. supply managers might shed light on potential recycling facilities.

Consumer Behavior Towards Recycled Cotton: An additional key variable for Gap Inc. to consider is how customers will behave with recycled clothing. Are customers willing to pay more for a recycled cotton garment and if so, by how much? Is there a concern for the quality of recycled cotton garments and does this impact a decision to purchase? Such questions are key to the business case surrounding recycled cotton garments for Gap Inc., and should be answered prior to a full implementation of recycled cotton.

Competitor Pricing
To compare the pricing strategy of recycled products versus virgin products within the fashion industry the team analyzed H&M's relatively new 'Conscious' product line. This research appears to show that H&M prices their recycled, or 'Conscious', products at the same price point as traditional virgin products. For example, the H&M women's denim 'Girlfriend Jeans', which has both a 'Conscious' product option and a virgin option, are both priced exactly at $39.99 as of April 26, 2016. This seems to show that H&M believes there is no additional price that can be charged for recycled cotton garments. The reason for this can possibly be found in academic research, which is explained below.

Academic Research on WTP and Recycled Products
In a paper written in 2010, academic researchers analyzed seven different product lines and found that while a consumer's willingness to pay does increase for some products that are recycled, this price premium reduces when the consumers faces a "high level of functional risk."[28] In other words, a consumer is more willing to pay for recycled paper, which is relatively low in functionality, than a recycled technical product such a cell phone. Unfortunately, the seven products analyzed did not include any type of garment, however, it can be inferred that Gap Inc. consumers would consider their clothes to exhibit higher levels of functional risk when compared to more simple products such as recycled paper. The assumption behind this inference is that clothing, while technically simple, is highly functional in the view of a typical consumer, as they intend to wear their clothing numerous times.

From a more general perspective, researchers have tried to identify if customers are willing to pay more for environmentally friendly goods. While several have claimed that this link exists,

[28] Leila Hamzaoui Essoussi and Jonathan D. Linton (2010). "New or recycled products: how much are consumers willing to pay*?" Telfer School of Management, University of Ottawa*, doi: 10.1108/07363761011063358.

and that consumer behavior can help to shift the practices of large companies, there is still limited evidence that customers will pay more in practice and on a large scale.[29] [30] [31]

Conclusion

Using recycled cotton within Gap Inc. presents a large opportunity to create quality products that build brand reputation and reduce the negative impacts to society. Incorporating recycled cotton is not without challenges, and it is imperative that if Gap Inc. chooses to pursue recycled cotton it must maintain a long-term strategic mindset. Implementation will likely cause short term costs to rise, reduce profit margins, and add organizational complexity. However, in the long term, recycled cotton could provide a new source for cotton fabric, enhance brand reputation, and minimize downside risk associated with fast-fashion trends in the current marketplace. Taken together, Gap Inc. could be a fashion industry leader that continues to create great products while also creating value for shareholders and society as a whole.

[29] Hainmueller, Jens and Hiscox, Michael J., Buying Green? Field Experimental Tests of Consumer Support for Environmentalism (2015). Available at SSRN: http://ssrn.com/abstract=2062429.

[30] Hainmueller, J., M.J. Hiscox, and S. Sequeira, Consumer Demand for Fair Trade: Evidence from a Multistore Field Experiment. Review of Economics & Statistics, 2015. 97(2): p. 242-256.

[31] O'Rourke, D., et al., Citizen Consumer. Boston Review, 2011. 36(6): p. 12-29.

Appendix

Appendix A. H&M vs. Esprit – Recycled Cotton Initiatives

The following analysis is reproduced from a report completed by Carla Li-Carrillo, William Porter Orr, Patrick Ford, and Bhanuteja Nadella *in the Strategies for Sustainable Business class at MIT Sloan, dated March 11, 2016.*

Introduction

The fashion industry is one of the most polluting industries in the world, behind only oil and gas.[32] As a catalyst for growth and consumerism, it is a true challenge to create a sustainable business in the fashion industry that is geared towards absolute, and not simply relative sustainability. In order to accomplish this, firms must be mindful of designing out and reusing waste, and ensuring that materials are sourced responsibly. All of this must be accomplished against the backdrop of ever changing and growing consumer demands. This is particularly true of 'fast fashion' retailers,[33] whose business model is dependent on encouraging customers to make frequent purchases. It is a known fact that with thousands of tonnes of garments being disposed of every year and potential shortages of raw materials, particularly cotton, the industry cannot continue producing the way it is today.[1]

As the fashion industry searches for a more sustainable business model, we are focusing on the sustainability strategies of two of the leading fashion brands at the forefront of recycling for the garment industry: Esprit and H&M. The evaluation of each firm's sustainability strategy involved an in depth analysis of their closed loop cotton recycling processes, paying special attention to the business opportunities and challenges inherent in each. For each of these firms, and generally for the industry, cotton recycling is moderately complex from a technical standpoint due to the challenges of scaling current processing techniques and ensuring the quality of the final product. From the standpoint of organizational complexity, multiple organizations are required in order to optimize the closed loop recycling process.

Sourcing

Cotton recycling involves the mechanical or chemical processing of fabrics that were previously dyed to create yarn for new products. Recycled materials are typically combined with virgin materials in the manufacturing of the final product. Both H&M and Esprit use "offcuts" from the manufacturing process as the main raw material in their recycling process. Offcuts are the cotton scraps that are left in the garment factories after the different garment shapes are cut from the fabric.

However, while Esprit limits itself to recycling offcuts, H&M also recycles garments collected from consumer donations at their retail stores in addition to the scraps. Donations are received

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[32] Sears, Joi. "How Cotton Recovery is Changing the Game for Sustainable Fashion." Triple Pundit - People, Planet, Profit, 04 Mar. 2016. Web. 05 Mar. 2016. <http://www.triplepundit.com/special/cotton-sustainability-c-and-a-foundation/cotton-recovery-changing-game-sustainable-fashion/>.

[33] Ringstrom, Anna. "Recycling -- Fashion World's Antidote to Environmental Concerns." *Reuters*. Thomson Reuters, 25 Aug. 2015. Web. 06 Mar. 2016. <http://www.reuters.com/article/us-fashion-recycling-h-m-idUSKCN0QT2AO20150825>.

through H&M's 'Global Garment Collection Initiative.'[34] Before submitting material to recycling, H&M first tries to find alternate use for the clothes: donating them for repurpose, repurposing them as cleaning material, repurposing them as insulation material, and only as a last resource recycling them to create new yarn.[35]

It is important to consider the sourcing of recycled cotton from the context of a closed loop system. Both companies are making efforts to include recycled cotton in their product lines, but only H&M is taking the extra step to collect and then recycle end of life garments from its consumers. This added level of complexity, on top of the recycling of factory offcuts, requires a detailed logistics strategy in addition to a plan for dealing with the inevitable heterogeneity of the collected products.[36] Therefore, it is our opinion that H&M is taking a more holistic approach to the sourcing of recycled cotton because a greater percentage of its waste is repurposed throughout its supply chain. This approach will add value to a greater fraction of waste products and have the potential to bring greater reductions in environmental impacts.

Recycling Process

While both Esprit and H&M recycle cotton, they use drastically different methods, both of which have different environmental footprints and result in different quality products.

Offcuts from Esprit factories are processed via mechanical recycling. Mechanical recycling takes previously spun fabrics, breaks them down, and then re-spins them into yarns.[37] Mechanical recycling can be performed on fabrics coming from post industrial production, from by-products created during manufacturing, or from post consumer use. Regardless of source, these fabrics must be sorted, cut up, and shredded into fibers. Then textiles must be 'carded' to disentangle, clean, and intermix these fibers. After carding, fibers can be spun into new textiles.[38] As a result of the cutting and shredding process, mechanically recycled fabrics have shorter fiber length and are not as resistant as virgin fabrics. As a result, it is not possible to make a garment out of 100% recycled material. By pursuing this option, Esprit cannot create entirely recycled garments. However, Esprit still produces products that are comprised of recycled materials: recycled denim fabric comprised of 43% recycled cotton and recycled T-shirt fabric comprised of 35% recycled cotton, with the remaining 65% of the t-shirt made from recycled polyester. Furthermore, Esprit emphasizes the recycled nature of these garments by neglecting to re-dye them, thus showing the blends of fabrics that went into producing the garment, rather than selling solid single colors.[39]

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34 "Garment Collecting." *Garment Collecting*. N.p., n.d. Web. 06 Mar. 2016. <http://about.hm.com/en/About/sustainability/commitments/reduce-waste/garment-collecting.html>.

35 "H&M Garment Collecting." *H&M Garment Collecting*. N.p., n.d. Web. 06 Mar. 2016. <http://about.hm.com/en/ImageGallery/asset-detail-page.html/videos/CSR/HM_Garment_Collecting.mov.html>.

36 Accorsi, R., et al., On the design of closed-loop networks for product life cycle management: Economic, environmental and geography considerations. Journal of Transport Geography, 2015. 48: p. 121-134.

37 Haule, L.V., C.M. Carr, and M. Rigout, Preparation and physical properties of regenerated cellulose fibres from cotton waste garments. Journal of Cleaner Production, 2016. 112(Part 5): p. 4445-4451.

38 "Textiles: Recycling Process." *Bureau of International Recycling.* N.p., N.d. Web 08 Mar. 2016. <http://www.bir.org/industry/textiles/>.

39 "Esprit - 2013 Recycled Collection by Esprit." *Esprit - 2013 Recycled Collection by Esprit*. N.p., n.d. Web. 06 Mar. 2016. <http://www.esprit.com/index.php?command=Display&page_id=9131>.

In 2015, H&M partnered with garment recycling company 'Worn Again.'[40] Worn Again recycles cotton waste through what is known as 'chemical fiber recycling.' The chemical recycling of fabrics is a relatively new technology that has yet to scale to widespread implementation. In this process garments are collected and purified (removing dyes & contaminants) and then made into a pulp using a chemical solution, which is speculated to have potential negative effects.[41] Then this pulp is recombined to create new fiber.[42] This fiber is then combed and re-spun to create new fabrics. Similar to mechanical manufacturing, fibers are damaged in this chemical process and are shorter than virgin cotton would be. As a result, they are not robust enough to make a 100% recycled cotton garment. However, using this process H&M creates 20% recycled cotton denim from its recycled cotton.[43]

We believe that Esprit has a better sustainability strategy in terms of the processing of recycled material. Esprit's mechanical process doesn't use potentially harmful chemical components that must eventually be discarded. Furthermore, Esprit offers a higher number of recycled products and each product contains higher concentrations of recycled cotton.

Market Success

Cotton recycling not only provides a host of technical challenges, but the final products created must also meet consumer demands for style and quality. Esprit's and H&M's recycled cotton collections vary in scale and have experienced different levels of success in the market.

Esprit has been in the business of recycled garments since as early as 2003, when they launched their 'Recycled Collection' exclusively in Asia. All garments from this collection are made from recycled offcuts from their manufacturing facilities.[44] This collection is particularly innovative in that it does not limit itself to recycled cotton: Esprit has developed and implemented recycling for many raw materials including wool, polyester, and nylon. The Recycled Collection is also pushing the boundaries of innovation every year, as it is designed by winners of the 'EcoChic Design Award,' "the world's largest sustainable fashion design competition challenging emerging fashion designers to create mainstream clothing with minimal textile waste."[45] Creating products using recycled materials while also focusing on innovative designs has allowed Esprit to differentiate itself in the clothing market.

In contrast, H&M launched the "Denim Re-born" collection in the US in 2015, a collection of 16 recycled denim garments. The collection, launched this past September, consisted of garments for men, women, and children. Thus far, the only product created for this initiative has been denim as H&M is currently only focusing on the recycling of cotton. Denim re-born is H&M's

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[40] H&M, Kering, Worn Again. *H&M, Kering and Innovation Company Worn Again Join Forces to Make the Continual Recycling of Textiles a Sustainable Reality*. N.p., 31 Mar. 2015. Web. 6 Mar. 2016. <http://wornagain.info/wp-content/uploads/WA-Kering-HM_press-release_31-1-2.03.2015_ENG_Update_nv_Final.pdf>.

[41] "Progress in separating, recycling, cotton and polyester blends." *Industrial Fabrics Association International.* N.p., n.d. Web. 08 Mar. 2016. <http://www.ifai.com/2015/07/15/progress-in-separating-recycling-cotton-and-polyester-blends/>.

[42] "The Evrnu Technology." *Evrnu.* N.p., n.d. Web. 08 Mar. 2016. <http://www.evrnu.com/technology/>.

[43] Tschorn, Adam. "What H&M Has Been Doing with Your Unwanted Clothes."*Los Angeles Times*. Los Angeles Times, 20 Aug. 2015. Web. 06 Mar. 2016. <http://www.latimes.com/fashion/alltherage/la-ar-h-m-launches-recycled-denim-20150820-story.html>.

[44] "Esprit - Sustainability in Practice." *Esprit - Sustainability in Practice*. N.p., n.d. Web. 06 Mar. 2016. <http://www.esprit.com/company/sustainability/sustainability_in_practice/>.

[45] "Home." *The EcoChic Design Award*. N.p., n.d. Web. 07 Mar. 2016. <http://www.ecochicdesignaward.com/>.

effort to create a closed-loop business and reduce environmental impact through the introduction of a new product. This product line also holds the possibility of reducing waste and process inputs from virgin materials, thereby reducing the costs and risks to H&M in the future.