ABSTRACT

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The purpose of this research study was to determine sustainability indicators which may form the basis of textile and apparel products and firms being promoted and marketed as sustainable. This research also aimed to help prioritize sustainable efforts in order to ensure effective progress towards sustainable development of the firm.

Sustainability is commonly defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Sustainability is a growing interest in the textile and apparel industry, being driven forward by both external and internal stakeholder. There are a variety of ways in which organizations can integrate sustainable activities into their business, and this research concentrated on product driven initiatives.

The study was an exploratory study aimed at understanding industry experts' opinions on the ease and implementation of various sustainable indicators. This study used a modified Delphi methodology with a non-random judgment sample of experts in the field of textile and apparel sustainability was used in order to gain insight into product and organizational sustainability. Participants were asked to complete a web-based survey which was composed of seven dimensions: materials, processing and manufacturing, packaging and distribution, aftercare and use, end-of-life, and social responsibility. Each dimension consisted of numerous sustainability indicators which respondents were asked to rate based on overall importance and ease of implementation. Respondents were also asked to choose the top three most important indicators from each dimension. Results were analyzed to make recommendations for the foundation of a basis on which textile and apparel products and firms must achieve in order to be promoted and marketed as sustainable.

Only five indicators were found to be suitable as requirements for which a product or firm must meet in order to be marketed or promoted as sustainable. These five indicators included

identifiable material components, measuring water use at facilities, measuring energy use at facility, communicating end-of-life options to consumers, and paying employees a living wage. Overall there was very little agreement from respondents on which indicators were important. Of the 61 total indicators rated, only 17 received average ratings above 5.0 in terms of overall importance (with 7.0 representing very important). Nine of these indicators were processing and manufacturing indicators, which often have direct impacts on economics as well. Of the 61 total indicators, only eight were rated below 3.0 in terms of ease of implementation (with 1.0 representing easy to implement).

Sustainability Insights

by
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BIOGRAPHY

Mallory Meagan McConnell was born in Boynton Beach, Florida, and raised in Asheville, North Carolina. Mallory is the daughter of George Witter McConnell and Sherry Jean McConnell, and the younger sister to Lindsay Brooke McConnell and George Morgan McConnell. Mallory graduated from Asheville High School in the spring of 2005. In the fall of 2005, Mallory relocated to Raleigh, North Carolina to pursue an education at North Carolina State University. In 2009 Mallory graduated Cum Laude from the College of Textiles at North Carolina State University with a Bachelor in Science degree in Textile and Apparel Management. While an undergraduate at North Carolina State University, Mallory participated in the National Student Exchange, and studied for a year at the University of Hawaii-Manoa.

In the fall of 2009, Mallory began her Master of Science in Textiles at North Carolina State University. While completing her studies, Mallory had the opportunity to work with a variety of faculty and students, and found her passion in the area of sustainable design and development of textile and apparel products. Mallory would like to pursue a career in sustainable development for the textile and apparel industry.

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Introduction

There is a trend of consumers pushing for more sustainable designs. Technology and advancements in production have made possible eco-friendly and less wasteful design. Recycled materials can be used as raw materials for production. Waste can be significantly diminished and often reused. Natural fibers can be grown organically, without the use of harmful toxins and pesticides. Apparel and textiles can be and are, recycled (Hawley, 2006; Gulich, 2006). Consumer to consumer sales and donations to charitable organizations has decreased the amount of textiles ending up in the landfill (Hawley, 2006). Small boutique designers are using post-consumer materials to remanufacture fashionable, up-to-date styles. Eco-efficient washers and dryers are saving energy on the consumer end, which results in savings of natural resources. Yet, the textile and apparel industry is still producing large amounts of waste, using large amounts natural resources, and polluting the air, land, and water stream.

Some researchers have indicated that the majority of environmental and societal impacts can be determined in the design stage (Niinimaki, 2009; Van der Ryn & Cowan, 1996; McDonough & Braungart, 2002). There are a variety of sustainable design programs, including design for recyclability, design for remanufacturing, design for durability and extended life span, design for reuse, design for the environment, design for eco-efficiency and design for end of life. Decisions made in the design stage may have great impact on the economy, environment, and human population. Although designers already have a variety of tools and techniques to gather information and assist decision making, many of these tools have boundaries which limit them from wide spread use.

Relevance

Several organizations have begun to track their sustainable development in terms of indicators. A widely adopted 1987 model divides sustainability measures into three broad concepts: environmental stewardship, social responsibility, and economic prosperity (Martins et. al., 2007). Depending upon role in the supply chain, indicators may be further segmented into categories such as water, energy, labor, transportation, and chemical responsibility (Sherburne, 2009). Retailers, government agencies, and certification organizations may develop their own set of sustainable indicators which encompass key policies and related issues for their concepts of sustainability. Currently there is very little regulation concerning a firm's measurement and reporting methodology for sustainability. Moore and Wentz (2009) found that this lack of unification in standards for sustainability complicates sustainable development as a whole, and makes measurement difficult.

Sustainable development is often measured by sustainable indicators (Krajnc & Glavic, 2005; Ledoux, Mertens & Wolff, 2005). Indicators may be quantifiable or qualitative. Quantifiable sustainability indicators allow for measurement of progress towards sustainability, and also identify specific areas which need improvement. The Eco-Index, a project initiated by the Outdoor Industry Association (OIA) and the European Outdoor Group, define indicators as "environmental performance parameters or attributes that demonstrate environmental impact or improvement" (Eco-Index, n.d.). The indicators of interest for the Eco-Index are environmentally based, but indicators may also be socially based or economically based. Many firms measure sustainability on many different indicators. Some indicators may be impacted by the design of a product, such as end-of-life options and material health. Indicators may also include many issues and principles which are not "commonly used by designers or found in the language of design" (Fletcher, 2002). Creating a set of sustainable indicators which can be used and influenced by design, and delivering these indicators in an applicable way to designers will allow for new products that advocate progress toward sustainability of the firm. Currently, companies are integrating sustainable efforts into their business practice and products in a variety of ways, and often there is not a uniform understanding of sustainability as a cohesive practice (Fletcher, 2009). Prioritizing sustainable indicators will allow for meaningful advancement toward sustainable development for the textile and apparel industry.

Objective of Research

The goal of this research is to determine sustainability indicators which may form the basis of textile and apparel products and firms being promoted and marketed as sustainable.

This research also aims to help prioritize sustainable efforts in order to ensure effective progress towards sustainable development of the firm.

Need for Sustainable Development

Rising consumption levels, rapid population growth, and diminishing natural resources all act as initiators for large scale sustainable development. Consumption of consumer goods, particularly textiles and apparel, is rising annually. In 2010, US$190.9 billion dollars was spent in the apparel industry and a total of 19.1 billion items were purchased by consumers (AAFA, 2010). This translates to approximately 61 garments for every person in the USA. Excessive consumption of apparel and footwear is well known in the USA. The USA has the largest per capita footwear consumption in the world, with 6.9 pairs of shoes per person annually (Rahimifard, Staikos, Coates, 2007). Imports of clothing has become extremely common, making up “91 percent in 31 of the 39 individual apparel categories for which the U.S. Department of Commerce’s Office of Textiles and Apparel (OTEXA) publishes data” (AAFA, 2007). Cost reducing negotiations by large brands and retail firms often limit the progress that can be made by overseas manufacturing firms. In addition, unscrupulous entrepreneurs are known to ignore many social regulations. Steady increases in consumption may also lead to steady increases in waste production. As landfills continue to expand, diverting textile and apparel products from the waste stream may receive increased attention from government bodies and municipalities. It is estimated that in the UK alone, post-consumer waste arising from textile and footwear is 1,165,000 tons annually (Rahimifard, Staikos, & Coats, 2007). Aside from increases in textile and apparel waste, limited raw materials also provide an incentive for sustainability in the textile and apparel industry. Many fibers require natural resources to produce, such as crude oil in the production of polyester and other synthetics, or large amounts of water needed to grow cotton. In the carpet industry, research has found that it takes five barrels of oil per hundred square meters to produce new carpet (Resource Recovery Forum, 2006). Natural resources are consumed in the harvesting and processing of fibers and also in their total lifetime use, care, and eventual disposal. According to the Centre for Remanufacturing and Reuse (CRR) key issues associated with clothing are resource consumption, greenhouse gas emission, land use, toxic production processes, landfill space, effects of globalization, workers' rights, health and safety, cultivation techniques, and animal welfare (Centre for Remanufacturing and Reuse, n.d.). New product design and development may offer creative solutions for many problems associated with current production, processing, use and disposal practices for the textile and apparel industry. In order to have significant impacts on issues associated with the design and development of textile and apparel products, a designer requires a usable information source and tool that provides a holistic view of the impacts of their design decisions. Benchmarking a bottom line for sustainable products also allows the entire industry to compete on a unified set of standards, which can progress sustainable development as a whole.

CHAPTER II

Literature Review

Textile industry and its effects

No textile manufacturing processes are absent from environmental impacts. “Several stages in the fiber-to-fabric process are environmentally problematic. Fiber production, dyeing, finishing, and other wet processes, drying, and shipping all impact air, water, and land quality” (Orzada & Moore, 2008). Even more impacts can occur in the use and aftercare stages, during laundering, care, and eventual disposal of consumer products. Consumer good production requires raw materials, energy, equipment, capital and labor. The processes and eventual consumption of these products produce effluents, emissions, solid waste, and other social, economic, and environmental impacts. Most of the environmental impact of a product is determined and locked in during design and product development (Orzada & Moore, 2008).

Much research has been done on segments of sustainable development; little has captured sustainability as cohesive practice. There may be different degrees, or levels of improvements towards sustainable development. Sustainable development at the global level is very large, and design of products may not have a significant impact. Design may have a larger impact at the firm or product level. There is also a need for sustainability at the consumer level, which requires educating consumers about their role in sustainability. Integrating sustainability into a firm’s actions can also happen at different levels. In his 2007 book, “Capitalism at the Crossroads”, Stuart Hart describes four levels of integrating sustainability into a firms strategic direction. The first stage is pollution prevention, where a firm works towards eliminating or minimizing waste before it is created. The second stage Hart describes is product stewardship, where the firm focuses on minimizing pollution and all environmental impacts for the entire life cycle of a product. The third stage is clean technology, where firms invest in emerging technology and new competencies. The last stage according to Hart is a sustainability vision, where firms work to create a framework to give direction for evolving products and services and competencies to meet these goals (Hart, 2007). Other researchers have defined these levels of sustainable integration as end-of-pipe changes, process changes, product changes, and system changes (Vellinga & Wieczorek, 2001). These levels of integration may be dependent upon their reach, whether they are aimed at local changes or global changes, and may also be a function of time, as global level systems change can take significant time, up to 25 years (See figure 1).

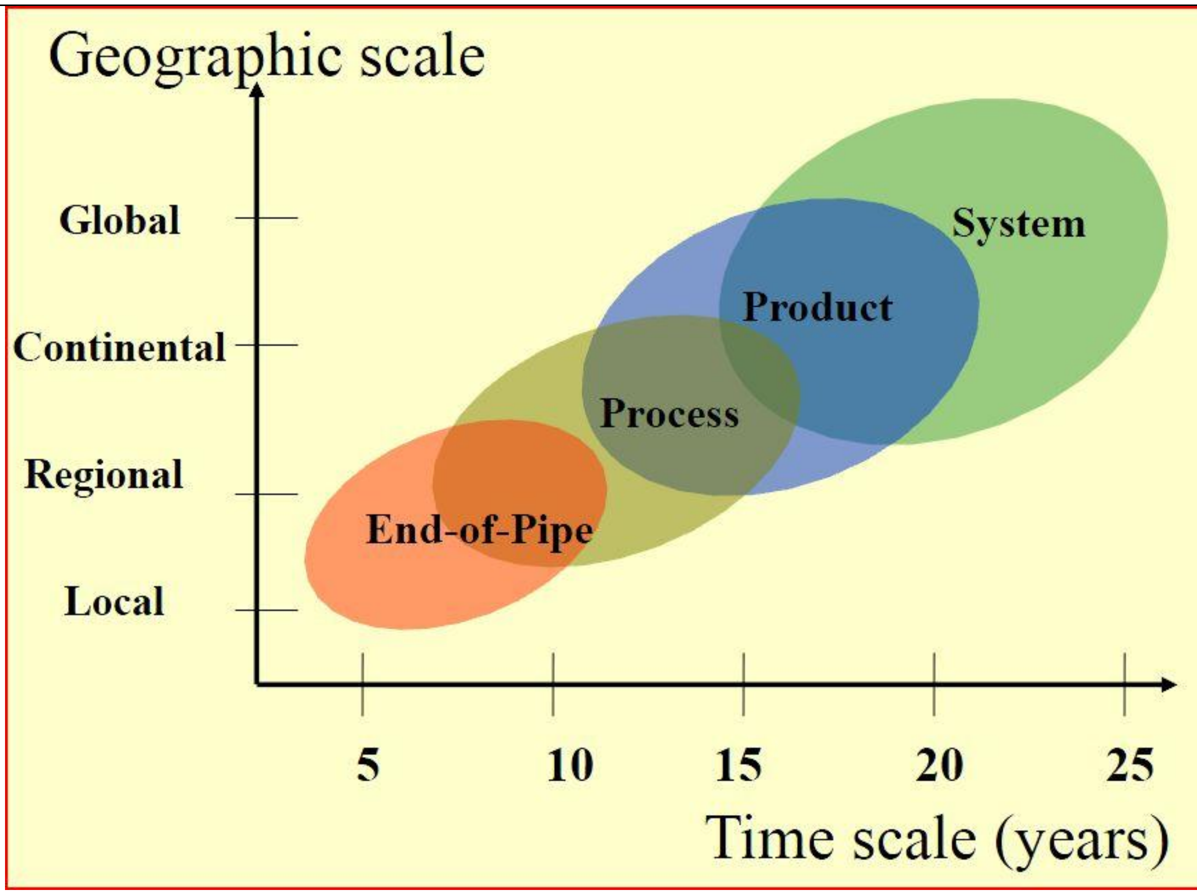

Figure 1: Societal Responses to the Issue of Environment, Vellinga & Wieczorek, 2001

In 2007 with the support of the Eastman Chemical Corporation, Whirlpool Corporation and the IDSA/EPA Partnership, the Industrial Designer Society of American (IDSA) developed and published an ecological design guide authored by Philip White, Louise St. Pierre and Steve Belletire. This guide is intended for designers and design students to provide an introduction into ecological and sustainable design practices. The guide provides Lifecycle Impact Assessment (LCIA) methodology, impact and global climate change value factors for 240 materials and processes, design guidelines for disassembly and recycling, as well as explorations into environmental ethics and bio-mimicry. The ecological design guideline outlines what they consider to be leading environmental impact categories affected by consumer products. Three broad categories were defined as ecological damage, human health damage, and resource depletion (2007). Ecological damage includes global warming, ozone depletion, acid rain, water eutrophication, habitat alteration, and eco-toxicity. Human health damage includes photochemical smog and air pollutants, health damaging substances, and carcinogens. Resource depletions include the depletion of fossil fuels, fresh water, minerals, and topsoil (Belletire, Pierre, & White, 2007).

Water

A 2004 study of the textile and apparel industry in the UK found that the industry used 90 million tons of water, representing 0.5% of the total UK water consumption (Allwood, 2006). Rising cost and possible water shortages provide incentives for dye-houses, chemical manufacturers, processing facilities and other consumers of large amounts of water to consider ways to reuse and reduce overall use. Although the motivation for water reduction and reuse may be attributed to the desire to maintain production throughout water shortages, and not out of general concern for the environment (Grizzle, 2003), the practice can lead to both cost savings and reduction of environmental impacts. Some textile facilities range from 20-50 gallons per pound of production, which has provoked the development of water and energy saving technologies for processes.

Reductions of up to 20% of overall water consumption have been reported due to process modifications (Grizzle, 2003). Although process improvements which result in water savings are important contributions towards sustainability, these incremental improvements may not be sufficient if production and consumption continue to rise at current levels.

Total water consumption during the manufacture, processing, and use of a product is difficult to estimate. Research has been conducted on measuring water use in different stages of a products lifecycle. Some reports or studies of water consumption may only concentrate on either cultivation of a fiber or the processing of a product. These limited reports do not actually take into account the total water consumption of a product over its entire lifetime, including laundering and aftercare. In 2002, Hoekstra and Hung developed a measurement which they called a ‘water footprint’. A ‘water footprint’ is intended to measures the impact of society on the global water supply. They define a nation’s water footprint as “the total volume of freshwater that is used to produce the goods and services consumed by the inhabitants of the nation” (Hoekstra & Hung, 2002). It differs from other water metrics, as it relates water footprint to the consumption of a nation, rather than to the production of a nation (Chapagain, Hoekstra, Savenije, & Gautam, 2005). In the textile and apparel industry, different fibers may require different amounts of water in both the cultivation or manufacture of the fiber, as well as the processing of the product. Natural fibers in particular require substantial amount of water during cultivation and processing. Many reports focus on the water consumption of cotton in particular, as it takes substantial amounts of water to both grow and process. In a 2010 report produced by the Swiss-based textile and technology conglomerate OC Oerlikon, cotton production was estimated to be close to 22.3 million tons (Oerlikon, 2010). Almost half of all the cotton grown in the US is rain fed, while the other half is irrigated (Fletcher, 2008). In 2005 a report on the water footprint of cotton by Chapagain, Hoekstra, Savenije & Gautam differentiated the two types of water used to grow cotton a ‘Green water’ or ‘Blue water’. ‘Green water’ is the rainfall, whereas ‘blue water’ refers to irrigated water (Chapagain, Hoekstra, Savenije & Gautam, 2005). Much irrigated cotton is grown largely in warmer climatic regions where water may already be in short supply, such as Egypt, Uzbekistan, and Pakistan (Chapagain, Hoekstra, Savenije, & Gautam, 2005). Water needed to irrigate cotton crops can range depending upon the climate. In Sudan in takes 29,000 liters per kg of cotton, and in Israel it takes 7000 liters per kg (Lauren and Hansen, 1997, as cited by Fletcher, 2008). Often, in under developed nations the infrastructure to get water to the plant is inefficient. “In Central Asia, perhaps the area of most inefficient irrigated cotton, 60% of the water is lost before reaching the fields” (Fletcher, 2008). Water use in the manufacturing of synthetic and cellulosic fibers may require less initial water, although overall water consumption can be fairly intensive in the production of acrylic and viscose as well (Fletcher, 2008). Polyester, however, uses significantly less water to manufacture. “Water use in polyester production is less than 0.1 percent of the amount of water required to grow cotton” (Kalliala & Nousiainen, 1999 as cited by Orzada & Moore, 2008).Water consumption studies are often difficult to compare, as measurements may be collected differently, or capture different phases of manufacture and processing. In 2010 a study on the environmental impacts of manmade fibers was performed by Berichte, and it was found from ‘cradle to gate’, that Lenzing Modal (acrylic) required 43,000 liters of process water, and 428,000 liters of cooling water to produce one metric ton of fiber (Berichte, 2010). The study found that water was mainly used as cooling water, accounting for 90-95% of total water use, while only 5-10% of water was used as process water (Berichte, 2010). “Process water” refers to water which is used and then contaminated and unfit for reuse. Water which is able to be reused or recycled is often referred to as “cooling water” (Grizzle, 2003).

Water is not only prevalent in the cultivation of fibers, but also needed in the coloration and wet processing of fabric and fibers. Wet pretreatments, dyeing and finishing, as well as laundering have been associated with excessive uses of fresh water, as well as the release of chemicals in waste water which may have harmful impacts on marine life (Allwood, 2006). Most natural fibers require extensive preparation before they are ready for dyeing, finishing, and processing. The initial washing with water or detergent, particularly of natural fibers, may create contamination of wastewater from pesticides or other chemicals applied during cultivation (Orzada & Moore, 2008). Cotton, silk, and wool in particular may require additional cleaning processes, such as scouring and bleaching, which also uses excess water as well as chemicals of high concern. Rayon has been found to be particularly problematic in terms of processing pollution. “Cuprammonium rayon has not been manufactured in the United States since 1975 because it requires dissolving cellulose in a copper ammonium solution before fiber extrusion into a water-bath. The wastewater from the cuprammonium process contaminates the water. Copper and other chemicals must be removed for the water to meet US standards for clean water, which is an expensive process” (Orzada & Moore, 2008). Dyeing and finishing require usage of large amounts of water, and often present the most problematic environmental impacts. Chemicals from dyeing which are not fully fixed onto the fabric may find their way into the water stream.

There are technological advancements in processing which have lowered overall water consumption. Waterless dyes, foam dyes, and other dyeing and finishing techniques have dramatically reduced water usage, and also significantly limit energy needed for processing. “Low-wet pickup finishing techniques use less water than traditional finish application methods, thus reducing drying costs as well as water usage” (Orzada & Moore, 2008). Foam application dye methods were found to use 80% less water, lower energy use, as well as lower chemical costs (Wallace, 2010).

Well-known companies are promoting products marketed for their minimal use of water in manufacturing and processing. Levi’s has developed a line of jeans branded ‘WaterLess jeans’, which uses a new finishing process which reduces water use on average 28-96% (EcoTextile News, 2010).

The average pair of jeans uses 42 liters of water in the finishing process, and can undergo between three and ten washing cycles (EcoTextile News, 2010). By combining multiple wet cycle processes and eliminating the water from the stone washing process, Levis is able to reduce its water footprint. Levi's has also advised their consumers to wash their jeans rarely in order to save water during the use and aftercare phase of their life cycle.

Aside from conservation efforts, recycling water is also a key component of sustainable development for the textile and apparel industry. In a UK study conducted on input and outputs for the clothing and textile industry in 2004, it was found that the UK based industry produces 70 million tons of wastewater (Allwood, 2006). Limiting wastewater and subsequent effluents has advantages such as lower overall water use, lower pollution discharged, lower wastewater treatment costs, reduction in chemical use, and energy savings (Ergas, Therriault, & Reckhow, 2006). Water treatment can be an expensive process, where just decolorizing technology can range from $10 to $115 per thousand gallons of water (Ergas, Therriault, & Reckhow, 2006). The technology is available to recycle at least half of the existing plant effluent wastewater back into processing systems (Thiry, 2005).

Chemicals

Aside from excessive use of water, use of chemicals during production and processing is also a prominent issue facing the sustainability and environmental impacts of textile and apparel products. Textile and apparel products use a variety of chemicals in production, such as large amounts of pesticides and herbicides in the growth of cotton, as well as in various processing steps, such as cleaning, dyeing and finishing. As with water consumption, different fibers require different levels of chemical processing. Natural fibers generally require more chemicals in cleaning and preparation than synthetics. Wool, for example, must go through a cleaning process called scouring before it is ready to be processed into yarn. During scouring process, different chemical compounds are added to assist in the cleaning process. Sodium hydroxide and other Alkali are common chemicals added to the process, and are often associated with environmental contamination (Orzada & Moore, 2008). Research has found that almost one fourth of the United States consumption of pesticides is used to grow cotton (Allen, 2007 as cited by Baugh, 2008). Before cotton is harvested, defoliants are sprayed from planes, which cause the leaves of the plant to drop away and allow for easier cleaning. The chemicals used in the defoliants cause pollution to both the air and the water (Orzada & Moore, 2008). Before the dyeing process, many fibers, both natural and synthetic, are bleached to allow for more efficient color application. Bleaching traditionally is done with chlorine, which creates dangerous by-products, and can damage protein fibers. Hydrogen peroxide has been successfully substituted for chlorine although it is highly unstable (Orzada & Moore, 2008).

Dyeing and finishing activities have often been associated as the most polluting segments of textile production and processing. A variety of chemicals and auxiliaries make textile dyeing possible. According to the 2003 publication by the European Commission main chemicals and auxiliaries applied during the dyeing process include reducing agents, alkalis, salt, dispersing agents, complexing agents, and oxidizing agents (Reference Document on Best Available Techniques for the Textiles Industry). The European Commission reports on environmental issues caused by dyeing both resulting from the substances used, as well as the dyeing method employed. Substance issues may derive from the dyes, auxiliaries, basic chemicals, and other chemicals which remained on the substrate prior to dyeing (European Commission, 2003). Dye methods also present environmental issues. Batch dyeing requires significant amounts of water and energy, and continuous and semi-continuous dye methods require high concentrations of dyestuff (European Commission, 2003). Printing, although not very water intensive, adds pollution to the water from paste residue and cleaning (European Commission, 2003). Aside from negative impacts to the environment, dyeing has also been linked to human health issues as well. Most of the compounds used during dyeing are not only toxic, but known to be, or highly suspected to be, carcinogenic (Orzada & Moore, 2008). Some governments have gone as far as to outlaw certain dye families which are known to be particularly toxic. Europe has banned the use of 22 azo dyes which contain chemicals of concern, and has furthered the work to find alternative and safer chemicals to be used in dyes (Fletcher, 2008). Natural dyes have been noted as better for the environment, with lower energy and water consumption, although the need for consistency and quality hinder it from wide use (Slater, 2005 as cited by Orzada & Moore, 2008). Finishing activities also use large amounts of water, energy, and chemicals. Some finishing chemicals contain toxics, specifically heavy metals such as copper, chromium, and cobalt, as well as dioxins, and formaldehyde, all of which are known or suspected carcinogens (Fletcher, 2008).

Chemicals are also used to allow fibers and yarns to be spun, knit, or woven to add strength and avoid breaking. Lubricants used in spinning, oils used in knitting, and size used in weaving, must be washed out, and can be difficult to treat and slow to biodegrade (Fletcher, 2008). Sizing agents are of particular concern, as the process to remove size, the desizing step, is done with large quantities of water, and processes chemicals. The desizing step produces effluents which are especially polluting (European Commission, 2003). Sizing agents can be reclaimed and reused if high quality size agents are used, but often, cheaper starches are used which are difficult to recover and must be treated before released (Fletcher, 2008). Cotton fibers may contain other harmful chemicals, such as pentachlorophenols (PCPs), which act as a rot-proofing agent to protect it in storage and transport, and are also washed out in desizing. Certain governments, such as the United States as well and the European Union, have outlawed these substances for their effects of human health and carcinogenic properties (Fletcher, 2008).

A large issue associated with the use of toxic chemicals in the production and processing of textile and apparel product is the accumulation and pollution of land and water. “Synthetic fibers from a carbon-based chemical feedstock persist and accumulate in the environment because microorganisms lack the enzymes necessary to break the fiber down" (Fletcher, 2008). Along with chemicals used in the actual production of textiles, many chemicals of concern are present in treatments and processing, such as dyes, finishes, and other processing steps. Almost all consumer textile products have been treated with some sort of finishing treatment (Orzada & Moore, 2008). "Unless chemical treatments (such as dyes and finishes) are carefully selected, they can persist in the soil after degradation, contaminating land and water with toxins released from multiple, tiny dispersed particles" (Fletcher, 2008).

Many advances in technology and best practices have been developed to help limit the negative environmental and human health issues associated with chemical use in textile production and processing. Organic agriculture practices have been developed to grow cotton without the use of petroleum-based, and often toxic, chemicals such as fertilizers and pesticides (Organic Exchange, n.d.). Dyeing and finishing technology has also been advanced to use less water, energy, chemicals. Recycling and reclamation technology reduces waste and pollution, as well as overall cost. Dye companies have worked to develop more sustainable dyes. Huntsman Pte Ltd, a dye and chemical manufacturer, offers a chrome-free range of dyes for wool, as well as metal-free reactive dyes (Thiry, 2010). Cationic dyes are also receiving renewed attention as being more environmentally friendly, as it requires no salt, no alkali, and can be done at relatively lower temperatures (Thiry, 2010). Shanghai Newtech Textile Co. has also developed technology which allows for transfer printing to be done at room temperature.

A variety of governmental, non-governmental, and industry standards and groups have been developed to address the issue of toxic chemicals in consumer products. Oeko-Tex®, based in Switzerland, provides global information on the environmental friendliness of textile products to designers, product developers, retailers and consumers (Orzada & Moore, 2008). The European

Union has also taken steps to address toxic chemicals present in consumer products. The European Union has taken a proactive approach to regulating the use of chemicals in consumer products. Before 2003, pollution regulations were largely concentrated on end-of-pipe issues, but more recently the European Union has developed more regulations aimed at upstream partners (Fletcher, 2008). In 2007, the European Union has enacted legislation applying to chemicals made, used, sold, and imported into the European Union. The Registration, Evaluation and Authorization of Chemicals, commonly known as REACh, requires a European Union importer to register chemicals present in the imported product (Patterson, 2011). Under the REACh legislation, most harmful chemicals are known as Substances of Very High Concern (SVHC). SVHC are defined as "substances that have hazards with serious consequences, e.g., they cause cancer, or they have other hazardous properties and/or remain in the environment for a long time with their amounts in animals gradually building up" (REACH UK Competent Authority, 2009). Although REACh is not designed as a Restricted Substance List, it does provide a list of chemicals found to be of very high concern, and any chemical which appears on this list present in quantities higher than 0.1%, has special rules which apply (Patterson, 2011).

Oeko-Tex® developed two standards to address the issue of unsafe substances in textile products: the Oeko-Tex 100 and the Oeko-Tex 1000. The Oeko-Tex 100 was introduced in 1992, and tests for harmful substances in textile raw materials, as well as intermediate and end products. Harmful substances tested for include substances that are banned or controlled by law, as well as substances that are suspected to be harmful, but not yet banned or regulated (Orzada & Moore, 2008). The Oeko-Tex 1000 covers production procedures as well as disposal acts, and is a supplement to the Oeko-Tex 100 standard. An organization is not eligible for the Oeko-Tex 1000 certification without having previously satisfied all requirements for the Oeko-Tex 100 standard. These standards are globally accepted certifications, and ensure all international government requirements have been met (Orzada & Moore, 2008).

The American Apparel and Footwear Association also works to educate industry on restricted substances by the development of a Restricted Substance List (RSL) as well as chemical management systems which provide information on best practices (Orzada & Moore, 2008). The American Apparel and Footwear Associations RSL was created by their environmental task force, and is intended to ‘provide apparel and footwear companies with information related to regulations and laws that restrict or ban certain chemicals and substances in finished home textiles, apparel, and footwear products around the world’ (American Apparel and Footwear Association, n.d.). Many companies have developed their own internal RSL, such as Nike Inc., and the Timberland Company, which outline chemicals of concern for their products. Eventually it may be beneficial to collaborate and integrate these numerous RSL’s to ensure consistency within the industry. Incorporating RSLs into one database will ensure that all chemicals of concern are identified, and can allow investigation into discrepancies between RSLs.

Globalization of markets has resulted in products made from numerous sub-parts sourced from a variety of places. Because products can have so many diverse components sourced from a variety of places, it may be impossible and costly to identify every chemical contained (Braungart, McDonough, Bollinger, 2007). Similar to substances of very high concern (SVHC), there are some chemicals, which Michael Braungart and William McDonough of the McDonough Braungart Design Chemistry, identify as X-chemicals, which are known or suspected to be highly toxic, and which should be replaced and phased out of use (Braungart, McDonough, Bollinger, 2007). Firms can develop lists, similar to RSLs, pertaining to their particular industry of common ‘X-chemicals’ used, and replace them accordingly. Substituting known toxic chemicals with healthier alternatives is an approach to reducing the issues associated with toxic chemicals. Eco-effectiveness looks to improve the quality of the outputs, rather than minimize them (Braungart, McDonough, Bollinger, 2007). Eco-Intelligent polyester, which is produced by Victor Innovatex, is leading the way towards effective closed loop systems in the apparel and textile industry. Working with MBDC and EPEA, Victor Innovatex was able to produce polyester in which the chemical inputs were reduced from 57 to 15, and more were replaced with safer alternatives (McDonough & Braungart, 2002). Traditional processing and dyeing of polyester uses a known carcinogen, antimony. When subjected to high temperatures, antimony produces antimony trioxide, which pollutes wastewater and poses serious health concerns (McDonough & Braungart, 2002). Most current recycling processes for polyester also require high temperatures. Victor Innovatex, MBDC, and EPEA worked together to eliminate waste and toxic byproducts at the design stage, reevaluating and substituting raw materials in the molecular state. Eliminating or replacing toxic chemicals or other chemicals of concern during the design stage produces products which are healthier for both the human population as well as the environment. Eliminating a number of chemicals also may save money in raw material costs. Victor Innovatex was able to replace antimony with titanium and silica based catalysts, which have no known harmful effects (McDonough & Braungart, 2002). Victor Innovatex was able to do this without compromising existing traditional design requirements, such as color choice and weave design potential.

Materials

Products are generally made of more than one material, and the sustainability of that product is based on economic, environmental, and social impacts of that material through various life stages, including material extraction, manufacturing, packaging, transportation, consumer use, and disposal (Ljungberg, 2005). Researchers have outlined basic tenants for the selection of sustainable materials. Often they include selecting materials which reduce emissions and negative environmental impacts over their entire lifetime, are sourced from renewable resources, and contain recycled materials. Other considerations include reducing overall material use, increasing product efficiency, and sourcing fibers with documented traceable feedstock sources, among many others (Eco Index, 2010; Ljungberg, 2005).

The basic components of textile and apparel products are fibers, so it is feasible that sustainable fiber choices and materials are the first step to sustainable products (Baugh, 2008; Thiry, 2007). Fiber content for apparel has primarily been related to consumer value and aesthetic choices (Baugh, 2008). Aside from consumer demands and aesthetics, price, availability, and timely delivery are also of high consideration for product developers and retailers (Baugh, 2008). The goal of minimizing environmental impacts of fibers must be achieved while also meeting the needs and wants of consumers (Thiry, 2007). Without providing these consumer benefits, products will not be successful at market, and therefore, not sustainable. Because sustainability is not a large consideration during initial materials considerations, sustainable practices have often been left to processing and end-of-pipe activities (Baugh, 2008; O'Neil, 2010).

In general, most fibers fall into one of two categories: natural or man-made. Natural fibers are divided into two groups: animal fibers and plant fibers. Animal fibers, also known as protein fibers include wool, cashmere, alpaca, and silk. Plant fibers, also known as cellulose fibers, include bast fibers and seed fibers. Plant fibers include cotton, flax, hemp, jute, ramie, and others (Organic Exchange, n.d.). Manufactured fibers may be broken into two broad categories of regenerated fibers and synthetic fibers. Regenerated fibers are fibers which typically use a natural material which is converted into a fiber through wet-processing. Synthetic fibers are made from a chemical process, and are largely petro-chemical based (Organic Exchange, n.d.). Examples of regenerated cellulosic fibers include viscose, Modal, and Lyocell. Synthetic fibers include polyester and nylon, as well as acrylic, polypropylene, and PVC (Fletcher, 2008).

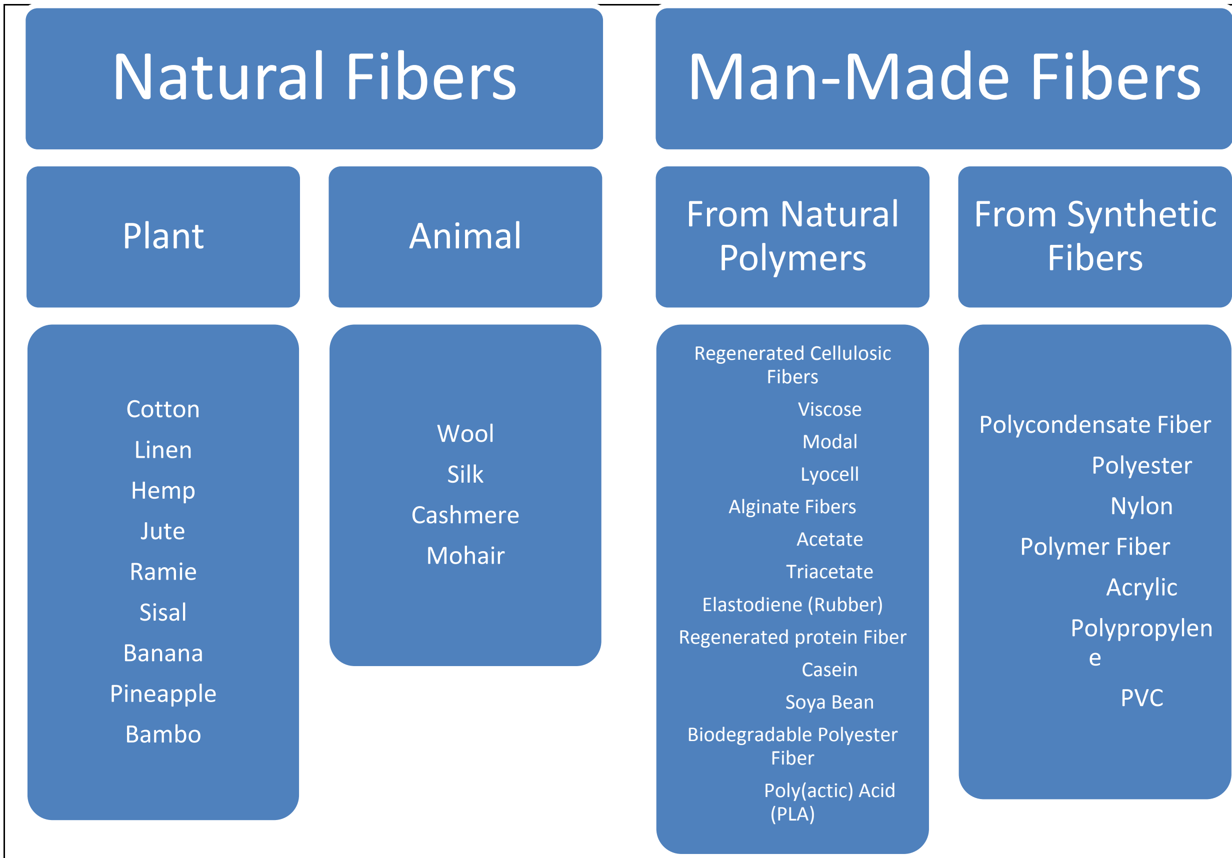

Figure 2: Textile Fiber Types, Fletcher, 2008

In 2000, the total global supply of fibers was 52.6 million tons (Oerlikon, 2010). In 2005, that number increased to 59.54 million tons, of which almost half, 25.76 million tons, were natural fibers, primarily dominated by cotton (Fletcher, 2008). 33.78 million tons were manufactured fibers, primarily dominated by synthetics with polyester being the most dominant (Fletcher, 2008). In 2009, the global fiber demand has increase significantly to 70.5 million tons with an annual growth rate of 3.3% (Oerlikon, 2010). From 2000 to 2009, synthetics and man-made cellulosics have grown 4% and 3.6% respectively. Cotton has only seen a 2.6% growth, while wool has seen a 2.2% decline (Oerlikon, 2010). Man-made fibers have continued to rise in popularity, which may be due to price and availability. In 2009, natural fibers represented only 26.3 million tons of the total market, while man-made fibers accounted for 44.1 million tons (Oerlikon, 2010).

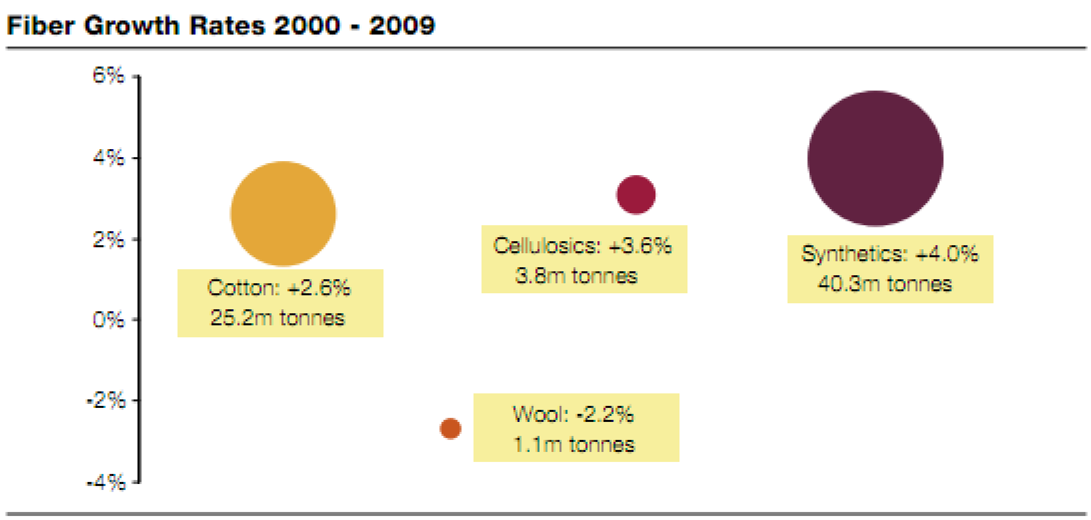

Figure 3: Fiber growth rates 2000-2009, Oerlikon, 2010

More recently, unconventional natural fibers, such as hemp, ramie, jute, corn, and bamboo fibers, have been gaining popularity in textile and apparel applications. Some of these untraditional fibers may have many environmental, social, and economic benefits. Hemp has natural tendencies to resist pests and mildew, requires significantly less water than cotton, and can grow in a variety of climates (Baugh, 2008). Hemp has also been found to have good moisture absorption, almost three times higher than cotton (Oerlikon, 2010). Other environmental advantages of hemp include resiliency, no chemical additives required for fiber splitting, and versatile usage for all parts of the plant (Oerlikon, 2010). Ramie, known to be resistant to mildew, quick drying and absorbent, and strong, can also be grown in many countries. Jute also is resistant to mildew, bacteria, and insects, has good strength and fair abrasion resistance. With advancements in finishing and processing technologies, many of these fibers have the potential to replace commonly used fibers which require more considerations during growth (Baugh, 2008).

There has been interest and success throughout the 1990's and 2000's of organic, natural, recycled, fair trade and rapidly renewable fibers (Fletcher, 2008). Organic refers to standards developed and defined in the USDA Organic Foods Production Act, passed and adopted by congress in 1990, which provides guidelines for production and certification of organic food. USDA Organic Foods Production Act sets time requirements to ensure the soil is free from toxic chemicals, and regulates farming methods and standards. Currently, the only fiber which meets USDA standards is cotton, and the cost and available quantities of organic cotton cannot meet total production requirements (Baugh, 2008). Organic cotton production is limited as cotton is highly sensitive to insects and weeds, and few places are able to support its growth without the use of pesticides and herbicides (Thiry, 2007). Aside from pest related issues which hinder the successful growth of organic cotton, there are also climatic issues which limit organic cotton growth. Organic cotton requires more arable land and therefore may not be suitable to large scale production (Thiry, 2007). Organic certifications may only apply to the farming and harvesting methods and do not necessarily imply that a final product is organic or environmentally friendly (Organic Exchange, n.d.; Thiry, 2007). A final obstacle for success of organic cotton and its applications is its susceptibility to fraud. There are no known physical differences between organic cotton and conventional cotton.

In 2005, the Global Organic Textile Standard (GOTS) was developed to define requirements and ensure organic status of textiles. The standard covers production, processing, manufacturing, packaging, labeling, exportation, importation, and distribution of all natural fibers (International Working Group on Global Organic Textile Standard, 2005). The standard sets criteria for processing, including restricted inputs, spinning, weaving, knitting, non woven manufacturing, and wet processing. The standard also covers environmental management, including waste water treatment, packaging, transportation, and social criteria (International Working Group on Global Organic Textile Standard, 2005). The Global Organic Textile Standard has support and sponsors including the U.K.'s Soil Association, the U.S. Organic Trade Association, the Japanese Organic Cotton Association, and Germany's International Association Natural Textile Industry (Thiry, 2007).

Aside from organic certification, materials derived from renewable sources are also indicated as sustainable materials. Renewable materials are materials which can be formed again in nature and have little or no environmental impact (Ljungberg, 2005). A tree cut down and used as a material can be considered a renewable material, as long as another tree is planted in its place. Polymers made from petrochemical sources are examples of non-renewable resources, as the oil cannot be easily replaced, and the use of oil has significant environmental impacts (Ljungberg, 2005). Cotton, for example, is a naturally cellulosic fiber, and is known as a renewable resource (Chen &Burns, 2006). Many researchers indicate that not only should materials be sourced from renewable resources, but should also be sourced from rapidly renewable resources. McDonough Braungart Design Chemistry defines a rapidly renewable material as "a material considered to be an agricultural product, both fiber and animal, that takes 10 years or less to grow or raise, and to harvest in an ongoing and sustainable fashion" (McDonough Braungart Design Chemistry, n.d.). Bamboo has often been cited as a possible sustainable material because of its ability to grow rapidly. Other benefits of bamboo include biodegradability, efficient space consumption, low water use, and carbon sequestering capabilities (Waite & Platts, 2009). However, the processing method for bamboo is identical to that used to make viscose or rayon, and can be polluting unless the process is carefully controlled and effluents are treated (Organic Exchange, n.d.). Although most natural fibers are considered renewable, not all are rapidly renewable. Renewable fibers are also not limited to natural fibers. Polylactic acid (PLA) has more recently received more attention because it requires only a large scale sugar as a raw material (Thiry, 2007), which is generally sourced from corn.

There are other examples of very non-traditional fiber sources which are being explored for their application in textile and apparel products. Helen Storey, a UK based fashion designer, has worked with Tony Ryan, a chemist at the University of Sheffield, to develop clothing made from a biodegradable polymer. The project is called ‘Wonderland’, and when submerged into water, the dresses dissolve (Storey & Ryan, 2005). The dissolving textiles were designed by Trish Belford, from Interface Inc., and although not intended to be applied on a large scale, the project aims to provoke consumers to consider what happens to their apparel at the end of life (Storey & Ryan, 2005). The science and technology used was also applied to plastic bottles, which dissolve when submerged into hot water. This technology has large implications for the packaging industry, where waste has been a large issue (Store & Ryan, 2005).

Cradle-to-Cradle certification calls for materials to be defined as either technical or biological nutrients. Technical nutrients are “materials specifically designed to ‘feed’ or be returned to industrial systems without any harmful effects”, while biological nutrients are “materials that can biodegrade safely and return to the soil to feed environmental processes” (McDonough & Braungart, 2002). Brands and manufacturers have been able to use this ideology to produce innovative products designed to continue in a value loop at the end of their life cycles. Victor Innovatex was able to develop two fabrics based on these principles. One, an Eco-Intelligent polyester is able to be recycled completely as a technical nutrient. Victor Innovatex was also able to develop a biological nutrient, which they have named Climatex ® Lifeguard FR ™. Climatex® Lifeguard FR ™ is made of organic woven fibers designed to be compostable. Climatex® is ‘made from natural ingredients which can be safely returned to the earth’ (McDonough & Braungart, 2002). Although Victor Innovatex was able to produce products made from both technical nutrients as well as biological nutrients, they do face an obstacles often associated with collecting and recycling consumer goods in the successful recapture of goods after their useful lives (McDonough & Braungart, 2002).

Although developing sustainable fibers and other basic building blocks for textile and apparel products may be the first step for many brands and designers in creating a sustainable product, there are other examples of creative use of materials to reduce negative environmental impacts. Looptworks began in 2009 as an environmentally forward company who repurposes pre-consumer waste to produce a limited number of clothing pieces. Based in Oregon, this U.S. company produces fast fashion, collection pieces, aimed at creating valued products using material which would be considered waste. Looptworks purchases small run fabrics from larger manufacturers to create their products. Left over fabrics and materials, which are not enough to produce a run large enough for many medium to large size manufacturers, are sourced and then sent to fair labor factory nearby for production (O'Connor, 2010). A Jalan shirt, a women's button down long sleeved shirt, takes only nine weeks to make, and is made of completely recycled materials. The company has a limited amount of materials, making each style in a small run. Each piece is numbered, increasing the image of a collectable piece. Adhering to strict quality standards, each piece is also built to last, increasing the life-span of the product and its legitimacy as a sustainable product (Looptworks, 2010). Some products do contain blended materials, which can make recycling difficult, and may limit the ability of the products to continue in a closed-loop cycle.

From Somewhere, an high-end fashion house out of London, utilizes discarded materials. Orsola de Castro is the founder of From Somewhere, and sources surplus fabrics from manufacturers to create upscale fashion pieces. More recently, she developed a 10-piece line of cocktail dresses made from obsolete Speedo swimsuits, which were banned by the swimming worlds governing body after the 2008 Olympics for giving athletes an unfair advantage (Williams, 2010). After this decision, Speedo was left with 18,000 swimsuits, and rather than discard of them to the landfill or incinerator, they donated them to de Castro. From Somewhere is a great example of creative material reuse.

Junky Styling is a company founded by Annika Sanders and Kerry Seager, which deconstructs and redesigns clothing found in the thrift stores, and retails their creations in a London-based shop. The team practices what they call ‘wardrobe surgery” and will also make custom alterations (Junky Styling, n.d.). The label was publicly launched in 1997, and remanufactures one or more garments into a recreated, artistic piece. Although one pattern may be used to create more than one piece, the raw materials will never be the same, therefore every piece created by Junky Styling is unique and one-of-a-kind (Mishara, 2010). Junky Styling is not unique in their attempt at restructuring used-clothing which might otherwise wind up in the landfill, however the application of this design method on a large scale may be limited.

Triad, Textile Recycling for Aid and International Development, is a charitable organization developed in 1999. Based in the UK, Triad operates 900 recycling banks specifically for textiles, and has 11 retail shops in London and Brighton. Aside from their retail shops which sell used clothing as is, TRIAD has also developed a label which reconstructs used clothing into garments called TRIADremade. TRIADremade utilizes designers to work with donated textiles to create original pieces that are not only good for the environment by reducing landfill waste, but also socially responsible, as profits are donated to help fight poverty (Textile Recycling for Aid and International Development, n.d.).

The Eco Index has developed guidelines to aid in material choices by developing material guidelines, indicators, and metrics. The scope and intention of the materials guidelines is to educate and provoke thought, as well as to be used as an educational tool. The materials guidelines cover 7 large areas of materials selection including understanding your footprint, material use efficiency, chemical responsibility, knowledge of your supply chain, durable material selection, product care and use, and design for end of life. These seven guidelines are measured by four material indicators, including recycled content, efficient utilization of inputs to create finished materials, chemical responsibility, and renewable content and source certification (Eco Index, 2010).

Waste

Textile Waste

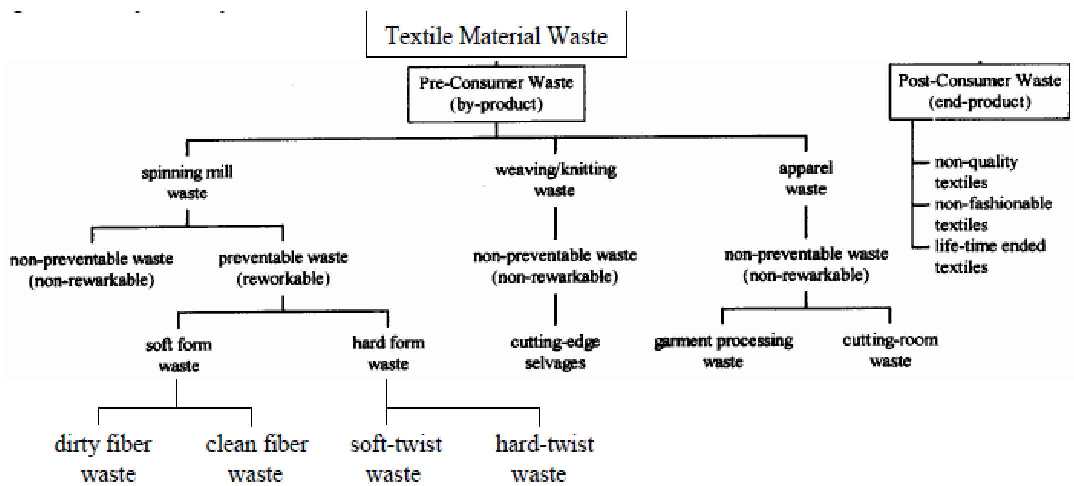

Figure 4: Classification of textile waste, El-Nouby, 2008

"Waste is any activity or product which consumes resources or creates costs without generating any form of offsetting value stream" (Sroufe, 2000). Waste occurs at almost every point in the production of textile and apparel goods, as well as use and disposal by consumers (El-Nouby, 2008). In the fashion industry product life cycles are often short, as frequent changing styles create the need for more products. Often apparel goods are replaced before they are worn out or no longer functional. Mass production, access to cheaper materials and labor, and a growing global middle class have made fast fashion obtainable for a mass market. Fashion seasons have increased, and in some cases retailers are seeing new products every two weeks. With this dramatic increase in the availability of new products with up-to-date styling, there has also been a dramatic increase in post-consumer textile and apparel waste, as consumers make room in their closets for new products. According to the United States Environmental Protection Agency, 12.4 million tons, representing 5% of total municipal solid waste, was generated in 2008. The EPA suggests that the textile recycling industry prevents 2.5 billion pounds of postconsumer textile product waste from ending up in the landfill, but a large amount of textile and apparel are still thrown away every year. In a study done on recycling by DEFRA in England for the 2006/07 year, it was found that only 1.3% of materials collected from households for recycling were textiles (DEFRA, 2007). According to a study done in 2004 of New York City household waste, of the textile waste disposed of clothing is the most popular textile item, linens being the second largest group, and carpets and upholstery being the third (New York City Department of Sanitation, 2005). The same study found that textile waste is not evenly distributed across every type of household. Researchers found an inverse relationship between income and textile waste generated, where higher income households disposed of less apparel goods (New York City Department of Sanitation, 2005).

Waste in the textile and apparel industry exists at both pre- and post-consumer levels. Pre-consumer waste may be composed of factory created waste. Post-consumer waste may be any waste generated during the use and disposal of textiles and apparel products by the consumer. Post-consumer waste is of particular interest, as there are many disposal options which could prevent textiles and apparel from being landfilled, and research into various motivations and methods of disposal of textile and apparel items by consumers is often lacking, out of date, or incomplete. Recycling, reuse, and repurposing are a few of the viable disposition methods for textile and apparel items. Each of these methods have challenges which must be addressed to be successful as a means of diverting textile and apparel goods from the landfill. Developing waste strategies to divert pre- and post-consumer textiles and apparel eliminates waste from the landfill and saves natural resources (Chang et al, 1999).

Diversion Methods

There are a variety of ways in which textile and apparel waste can be diverted from the landfill. Prior research done on this subject has resulted in many different process maps being developed. Bartl developed a map in 2006, which depicts the normal ‘cradle-to-grave’ flow of textile and apparel items, with three possible recycling options. The first diversion option was recapturing energy creating through incineration of textile and apparel items. The second option was reuse of the product without processing. The diversion option was breaking the end-of-life product back into fiber form to be used in the creation of new products (See Figure 5).

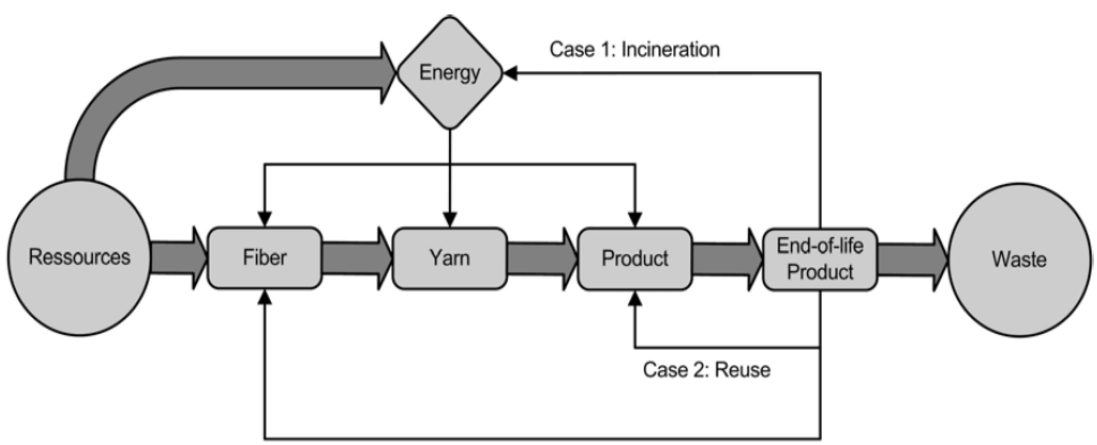

Figure 5: Cradle to grave chart with three recycling options, Bartle, 2008

Hawley created a more in-depth version of post-consumer textile waste diversion methods in her 2006 article. Hawley suggests that initially post-consumer textile waste is either donated to a charitable resale organization, or discarded to the landfill. Of those items donated to a charitable organization, some will be sold in a second-hand shop and a percentage will be sold to rag sorters. Items sold to rag sorters may be used in a variety of ways, or may also be discarded to the landfill (see Figure 6).

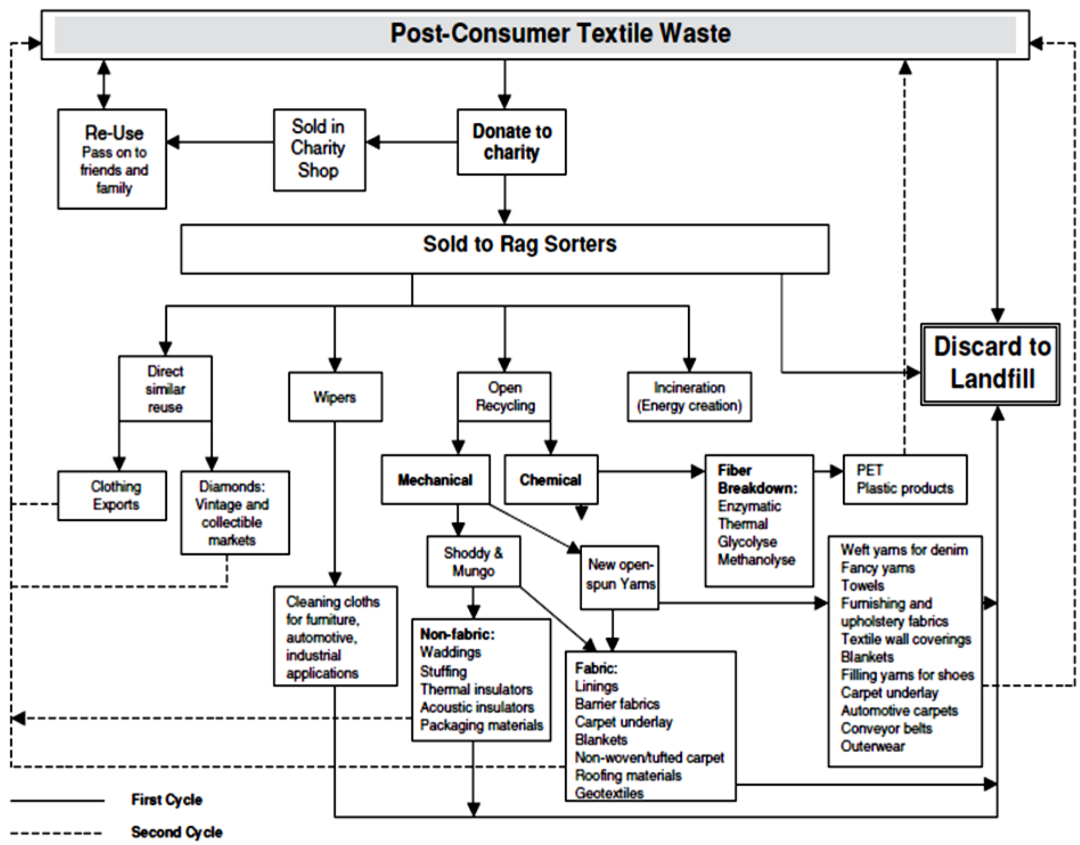

Figure 6: Post-consumer Textile Waste Map, Hawley, 2006

Each of these methods of diversion requires different amounts of energy, and some of the recapture may not be high. Some forms of waste diversion strategies should be preferred over others in terms of environmental savings. Incineration of fibers generally does not recapture enough energy to make it the most ideal form of textile waste diversion (Bartl, 2008).

Fraser developed another diversion map in 2009, which included upcycling in the possible diversion routes. Upcycling is the "process of converting waste materials or useless products into new materials or products into new materials or products of better quality or a higher environmental value" (Eco Index, 2010). Although there are firms performing this service for customers, largely this is done by the consumer (see Figure 7).

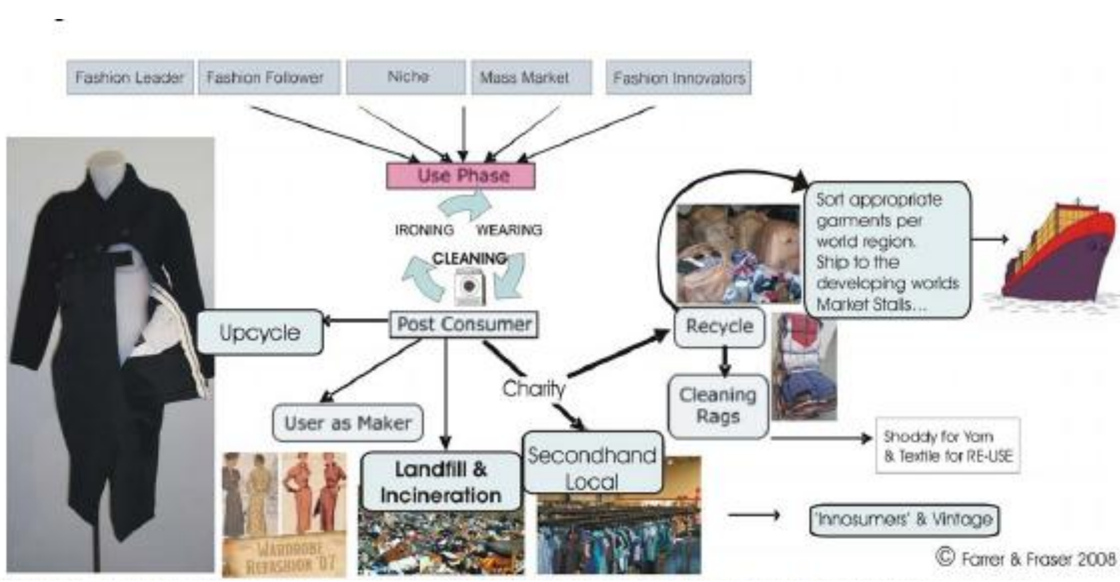

Figure 7: Diversion of discarded clothing from landfill, Fraser, 2009

In the United States, there are a variety of different types of organizations whose primary goal is to divert textiles from the waste stream, some which may be private organizations or government operated. Some municipalities have established curb side efforts to collect textiles. Each municipality operates differently in their collection efforts. Municipalities may collect textile every week alongside other normally recycled goods, such as glass, paper, and plastic (Platt, 1997). Others may limit collections to monthly or even annually. Other municipalities may not offer curbside collections at all, but will provide drop off sites for used textile and apparel goods. The type of textiles accepted may differ per municipality; some only collect clothing, while others will accept shoes, belts, and other accessories. If municipalities do collect textile and apparel curbside, some will only accept textiles which are separated and stored in weather resistant containers, due to possible damage from rain or snow. Others will allow textiles to be mixed with other recyclable items (Platt, 1997). Beginning a textile recycling program can cost municipalities very little, or possibly no money at all. Rag traders may pay anywhere from $80 to $160 per ton of used clothing, which is often enough to cover other recycling efforts (Platt, 1997). Convincing consumers to donate clothing to municipality run recycling efforts has often proven difficult, as many consumers would rather donate clothing to charitable organizations (Platt, 1997). Often municipality programs can work concurrently with private charity resale stores, as potentially there are too many goods for a private retailer to process. Private organizations can often provide an efficient means for collecting and transporting used textiles and apparel. Trans America Trading Company, a leading rag-sorter located in Clifton, New Jersey, collects post-consumer textiles and apparel in over 20 municipalities, mainly in the New York area (Trans America Trading Company, n.d.). They provide containers and transportation for the goods, and then grade the goods collected into a variety of secondary markets. Along with providing logistics for collecting used clothing, Trans America also provides education materials to market their service and increase participation among the communities (Trans American Trading Company, n.d.).

Pre-consumer waste can also be successfully diverted from the waste system. According to SMART, the United States Secondary Materials and Recycled Textiles Association, seventy five percent of pre-consumer textile waste is successfully diverted from the waste stream (SMART as cited by Fraser, 2009). In 1996, Grasso performed a study on recycling practices of factory fabric waste. Results found that 67% of factories land filled fabric waste, while 33% recycled the waste and 9% stockpiled their waste (1996). Of those who reported recycling waste, 32% cited selling their waste to a company specializing in recycling, 30% sold the waste to another manufacturer to use in its production, 12% used the waste within their own productions, and 7% returned the waste to the original manufacturer of the raw material (Grasso, 1996). Grasso found that the size of the firm did not have a large influence on recycling behavior; small and large firms both reported recycling. Waste was found to be significantly more valuable if sorted and free of debris. Some firms reported sorting their waste in terms of fiber content and color (Grasso, 1996).

Waste Strategies

Many organizations implement waste strategies in order to recapture value and lessen the environmental impacts of pre- and post-consumer products. There are different methods of waste strategies, such as recycling, reuse, and repurposing. There may be a hierarchical order to these strategies, as research has shown reusing pre- and post-consumer products to save the most overall energy, as no processing is necessary.

Recycling, reuse, and repurposing

Recycling can be defined as “any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original purpose or other purposes” (Eco Index, 2010). Recycling implies that the materials recovered would be considered waste. It does not include refurbishment or recapturing energy by incineration. Fiber recycling converts apparel and textiles back into fiber or polymer form to remanufacture into new products. Charity and consignment shops resell clothing to other consumers, and clothing can be reused without any processing necessary. Goodwill Industries International, Inc. is one of the largest charitable resale shops in North

America. Goodwill funds their charitable services through the resale of donated textile, apparel, footwear, and household items. Currently there are 2,400 Goodwill stores in North America which accepts new and used products. Goodwill donates 83% of their revenues directly to their charitable causes (Goodwill Industries International Inc, n.d.). Consumer to consumer sales of clothing, made possible through websites such as Ebay, or even rummage sales, has also enhanced the reuse of clothing to divert textile and apparel waste from the landfill. Small, boutique artists are recreating used apparel into trendy, one-of-a-kind collection pieces, which are then sold to consumers in small retail venues. Clothing not suitable for reuse can be turned into rags for the furniture and automotive industry.

In the 2009 study done by Farrant, Olsen, and Wangel, which specifically examine the Humana People to People resale shop in Sweden, it was found that 60 out of 100 garments collected would be reused. 20 would be resold in Humana stores, 10 would be sold to other second-hand stores, and 30 would be sent to African markets. Of the remaining 40 items not considered suitable for resale, 30 would be recycled as wipers, and 10 would be sent for incineration (Farrant, Olsen & Wangel, 2009). Research found that if it could be assumed that the purchase of a second hand good replace the purchase of a new item, then the purchase of 100 second hand clothing items would replace the purchase of between 60 and 85 new garments and significantly reduce the negative environmental impacts of clothing (Farrant, Olsen, and Wagnel, 2009).

Currently the most common textile recycling is in the form of charitable donations and hand-me-downs. The Bureau of International Recycling (BIR) states that textiles used in recycling originate from one of three sources: “post-industrial, a by-product from yarn and fabric manufacture for the garment making and retail industry, or as post-consumer, originating from discarded garments, household items, vehicles, etc.” (Bureau of International Recycling, n.d.). According to the BIR, the initial recycling process consists of 5 processes: sorting, re-sorting, shredding and pulling, carding, and spinning. During the initial sorting process textiles are divided into two initial categories: wearable and un-wearable. Wearable clothing is resold either domestically or abroad, whereas un-wearable clothing is sold to be shredded and respun. Un-wearable clothing may also be cut into rags, and sold to various industries, such as the automotive industry or the furniture industry (Hawley, 2006). The re-sorting process may categorize materials by type and color. Shredding and pulling aims to reduce the textile back into fiber form. Carding is used to clean and mix fibers, and spinning is used to create yarns which can then be used in weaving or knitting (BIR, n.d.). Some textiles may be easier more suitable for different recycling options. Synthetics may be more apt to return to raw materials, as the potential to reduce them back into a single polymer may be easy. Polyester-based materials, for example, may be returned back to polyester chips by cutting the garments into small pieces. These small chips may then be extruded into yarn (BIR, n.d.). Fabrics made with a variety of fibers may be more difficult to recycle for use in the production of new products, as separation of the blended fibers can be difficult if even possible. Blended fibers may therefore be more suited for reuse or restructuring.

Remanufacturing, refurbishing and restructuring are all based upon similar ideas of reprocessing an existing item for a new purpose. Refurbishing often occurs when a product has enough value to be resold at a price which covers the cost of refurbishment (Rogers & Tibben-Lembke, 2001). Currently remanufacturing has prevailed with aerospace, military, and automotive industries, where new items are expensive and durable. Items which are difficult to disassemble and have a low price may not be easily remanufactured. Research has also found remanufacturing to be motivated mainly by economic gains from recovering product value, rather than environmental concerns (Resource Recovery Forum, 2004). Remanufacturing may be less successful for products which are more affordable to purchase new than to remanufacture. In general, remanufacturing may be ideal for expensive products, which are built to last a significant amount of time (Resource Recovery Forum, 2004).

It has been found that nine percent of the hazardous municipal waste in the UK is currently incinerated for energy recovery (Rahimifard, Satikos, and Coats, 2007). There are a few general forms of energy recapturing for apparel and footwear, some of which are more established and generally accepted than others. Incineration involves the combustion of materials in order to recapture energy. Gasification is an emerging technology which produces a combustible gas out of carbon-containing energy to generate heat and electricity (Rahimifard, Satikos, and Coats, 2007). There are many possible negative effects of incineration, including toxic emissions into the atmosphere. Generally, not enough energy is recaptured from incineration to make it an ideal form of textile and apparel recycling.

The Outdoor Industry Association (OIA) and the European Outdoor Industry are currently developing an Eco Index for use by industry members in order to assess the sustainability of their practices and products, and to allow companies to benchmark and measure their environmental footprint, and identify areas for improvement. The Eco Index gives many guidelines on what constitutes a sustainable product by the development of indicators. The Eco Index developed a set of End of Life (EOL) guidelines and indicators. The eco-index design for EOL guidelines propose that products should be designed with materials which can be reused, refilled, repurposed, recycled, and retain financial value at the end of life (Eco-index- End of Life Guidelines, 2010). Other product guidelines include limiting number of materials, ease of disassembly, and designed to be durable, long-lasting, and have the performance/functionality maximized. The EOL guidelines also specify to avoid materials which may release substance of concerns during composting, biodegradation, recycling, incineration, or land filling (End of Life Guidelines, Eco-Index, n.d.). The Eco Index also specifies that if a product has a particularly short life span, or is single use, than it should be designed to be upcycled or recycled at product EOL (End of Life Guidelines, 2010). The concept of upcycling was revolves around retaining value of a material when recycled. Natural fibers require a certain length for viability in most yarn spinning. This may lead to a natural fiber only being viable for recycled once, if at all. The Eco Index does specify a hierarchy for each EOL design concept. The most preferred possibility would be a design intended for reuse, repurpose, refurbish and/or repaired. Recycling is the second preferred EOL option, mechanically recycling preferred over chemical recycling, and destructive EOL treatments being third. Managed compost is the most preferred destructive EOL treatment, followed by waste to energy, and finally landfill/incineration (Eco Index End of Life Guidelines, 2010).

Recycling

Recycling pre- and post-consumer textiles and apparel eliminates waste from the landfill, and saves natural resources. Often there is substantial waste at both pre- and post consumer levels, which could be successfully recycled back into production. For example, during the processing of virgin cotton materials, there is often a substantial amount (20-49%) of fibers discarded as waste before the product is available to consumers (El-Nouby, 2008). There are limitations for the application and success of recycling textile and apparel products. The quality of fiber and cost of processing can limit post-consumer textile recycling. Often end products contain blending fibers, dyes, and finishing agents, which can make recycling difficult and costly. Particularly with natural fibers, a significant length of fiber must be recaptured in order to be usable (Fraser, 2009). Once a natural textile or apparel product has been recycled once, the ability to reclaim and reuse those same fibers a second time is highly unusual. This is also applicable in man-made fibers, where the quality of a recycled product decreases after numerous recycling cycles. This concept is generally referred to as downcycling, which is defined as “the practice of recycling a material in such a way that much of its inherent value is lost and cannot be recovered following its next use” (Braungart & McDonough, 2002). Although there are currently successful methods for recycling synthetic fibers, there is still work to be done to ensure an energy efficient and safe process. Polyester, for example, can be recycled through a chemical process, but the process is expensive, and not necessarily environmentally friendly (El-Nouby, 2008). There are a variety of methods developed to recycle textile fibers, some using mechanical processes, and others using chemical based processes. In their 2006 study, Bartl and Marini mapped a mechanically based process for the recycling of fibers. Because the process requires no chemicals, the energy consumption was significantly lowered since there was no need for drying. Also, the need to recycle waste water was eliminated (Bartle & Marini, 2006). The process proposed by Bartle and Marini consisted of 5 steps: crushing, magnetic separation (to remove non-fiber materials), aerodynamic classification (an additional step to remove non-textile materials), tailoring, and fiber characterization. Tailoring isolates an individual fiber, and may provide long fibers which can then be spun into new yarns, or relatively short fibers which may be used in other end uses such as viscosity modification, composite reinforcement, or nonwovens (Bartl & Marini, 2006). If the original textile product was of low quality, the reclaimed fibers may not be applicable in the creation of new textile products. There have been processes developed which can use only recycled fibers and still maintain high quality (Grasso, 1996), but even still some fiber recycling combines recycled fibers with virgin materials to keep processing and final product quality high. Apparel and textile recycling has not been as popular as other product recycling, such as paper, plastic, and glass, until more recently (Koch & Domina, 1999). Currently, many firms are investigating ways to integrate recycling into their business. Burlington Denims and Levi-Strauss developed recycling programs which take pre-consumer waste and recycle it back into new products, eliminating waste, and saving natural resources which are required to grow virgin cotton. Recycled cotton can be found in a variety of products such as stationary (envelopes, paper), household insulation, and carpet pads (Change et al., 1999). Nonwovens are the largest market for recycled post-consumer fibers because processing takes less labor, equipment, time and money (Change et al., 1999). One of the first steps in any recycling effort is to identify components within the product to be recycled. Fiber content can be identified by performing microscopic tests or solubility tests if there is no fiber content label. Studies conducted by Change et al. found that the most common fiber content of used clothing was 100% cotton, 100% polyester, cotton/poly blends, and a nominal amount of acrylic. Based on their findings, they developed a set of eight products which were most suitable for recycled postconsumer textiles: carpet cushion, home insulation, fiberfill stuffing, clean-up products, mattress pads/futons, geotextiles, landscaping, and concrete reinforcement. Change et al. chose these eight products based on their ability to uphold performance characteristics, competitive pricing, and that there would be no need for cleaning, dyeing or finishing. Most of these products do not currently use recycled materials, and there exists room for growth (Change et al., 1999). Often fibers and fabrics are not designed with recyclability at the end of life as an important design requirement. Waste from textile and apparel processing is well defined, and can often be recycled. Machinery and advances in technology has made it economically feasible and fast to make reclaiming fibers as raw material a real possibility. Garment components can be separated by machine, making the separation of textile and non-textile materials easy. Machinery has also aided in getting fabric back to fiber form quickly. Advances in collection systems has made acquiring clothing from consumers at the products end-of-use or end-of-life possible, and continued research and development will help make post-consumer textile recycling an economic and viable option. There are parameters, however, which limit the applicability of full cycle fiber recycling. Bartl suggests that fiber content, fiber blends, ability to be processed, and existence of problematic by-products, all limit the potential for fiber recycling (2008). Some of these parameters can be directly controlled by designers during initial materials selection. In a 2006 study done by Allwood, it was found that there were energy savings from recycling fibers, although they were not as high as energy saved from the reuse of products. PET was found to use 93 GJ of energy to produce, and only 8 GJ were needed to reacquire and grind the fiber. This represented savings of 85 GJ of energy (Allwood, 2006 as cited by Bartl, 2008).

Full cycle material recycling is also present in the footwear industry. Some brands, such as Nike Inc., have established recollection programs to reacquire their products for material recycling. Through a variety of collection sources, including retailers, universities, and sports stadiums, shoes are collected and then sent to a recycling center where they are shredded for applied to a variety of end-uses such as running tracks, tennis and basketball courts, and playgrounds. Nike Inc. uses two techniques to recycle their shoes, the ‘slice-and-grind’ technique, where shoes are separated into three components, outsole, middle sole and upper part. The second technique grinds up the entire shoe as a whole component and then sends the output through a complex separating process. Nike Inc. has collected and recycled 250,567,779 pairs of shoes since 1990 (Nike Inc. Shoe Recycling & Sustainability, n.d.).

In 2005, Patagonia added the Common Threads Garment Recycling program to their list of environmentally reducing efforts which already include using 100% organic cotton and the development of their synchilla jackets, made from recycled soda bottles. Patagonia partners with a Japanese company, Teijin, to develop new polyester fibers from old capilene base layer garments using the Ecocircle™ recycling method. By using reclaimed materials Patagonia hopes to limit the natural resources required to make virgin polyester, as well as divert products from the landfill. Patagonia has expanded their recycling efforts to include used Polartec-branded fleece garments by Patagonia or any other company, and Patagonia cotton tee shirts. Although the fossil fuel input needed for processing virgin materials is greatly reduced, there is still the fossil fuel needed to transport used clothing from the U.S. to Japan. Patagonia conducted a detailed analysis of the energy use and CO^2 emissions created using three different scenarios: the virgin polyester creation process, the Ecocircle™ recycling process using locally recycled goods, and their current Ecocircle™ process using capilene base layers recycled from various sources. They found that option B, which utilizes local recycled goods, yielded the least amount of CO^2 emissions, and required the least amount of energy (0.98 metric tons CO^2 and 11,962 MJ of energy). Their current process, although not as ideal as the locally recycled process, still used substantially less energy and produced less CO^2 than Teijin's traditional polyester production process (1.20 metric tons CO^2 and 17,733 MJ energy). The original process of producing PET without recycling used 72,422 MJ of energy and produced 4.18 metric tons of CO^2 (Patagonia's common threads garment recycling program: a detailed analysis, n.d.). Patagonia hopes to limit other energy required in recycling by encouraging consumers to mail in used garments rather as opposed to dropping them off at retail stores. After conducting research, Patagonia found more energy was used and CO^2 was created from moving products domestically from consumers to stores than from shipping goods to Japan (Patagonia's common threads garment recycling program: a detailed analysis, n.d.).

Reuse

Reusing and reselling used clothing has been practiced for centuries. In post-industrial eras, consumers sold old, unwanted clothing in markets, where even rags had value (Welters, 2008). This practice still exists in developing nations, where used western clothing can be found on street corner racks and in markets (Hawley, 2009). This practice is not isolated to less developed nations. In the United Arab Emirates there is a second-hand clothing market for the immigrant population who provide service for the wealthy (Hawley, 2009). Much of the research on the social aspects of exporting used clothing relates to the impacts on the local textile industries of the importing country (Haggblade, 1990; Hawley, 2006). Many countries, including Kenya, Nigeria, Haiti, and India have all banned imports of used clothing at one point out of fear of local production disruption (Haggblade, 1990). Additionally, second world countries may not have an infrastructure capable of handling extra waste which may be produced by donations from developed countries (Oxham, 2005 as cited by

Rahimifard, Staikos, and Coates, 2007).Although disruption of local economies and transfer of waste should remain of high concern, research has found that cheap clothing provided by imports from developed nations act as a significant source of needed clothing for citizens of developing nations (Hawley, 2009). Although trade data does not usually set worn or used clothing exports into its own category, according to the International Trade Centre, the U.S. exported 1.4 million dollars worth of “other made textile articles, sets, worn clothing, worn textile articles, and rags” in 2009 (International Trade Centre, n.d.).

In the past most second hand clothing was bought and sold at church rummage sales and yard sales. More recently, there has been a rise in second-hand venues, such as Goodwill, the Salvation Army, and other charitable organizations (Welters, 2008). Studies in the UK report that over half of consumers have purchased from a resale shop (Watson, 2008). However, these statistics may not necessarily reflect environmental benefits. Consumer’s view second hand clothing differently than new clothing and it may not be correct to assume that second-hand clothing purchase is replacing the purchase of new clothing, and therefore the environmental savings may not be generalized (Farrant, Olsen, and Wangel, 2009). However, not all clothing collected in second-hand stores is sold. In a 2009 study done on a Swedish resale shop, it was found that 40% of the clothing collected was deemed not suitable for second-hand use and therefore discarded to the landfill (Farrant, Olsen, and Wangel, 2009). There are other end-of-life options for clothing not suitable for resale, such as the creation of wipers and rags. On average, research has predicted that only 15% of the second-hand shoes recollected from consumers are sold again for reuse, and the other 85% are disposed of in the landfill (Rahimifard, Satikos, and Coats, 2007). This is a worrisome statistic as many textiles are 100% recyclable (Hawley, 2009).The research on the motivations behind consumers purchasing used apparel has been mixed. Research has shown that price has a large effect on consumers to purchase used goods, and allows consumers access to products and labels they might not otherwise fiscally be able to afford (Watson, 2008). In terms of energy use, apparel and textile reuse can be argued to have the least negative environmental impact (Bartl, 2008; Farrant, Olsen, and Wangel, 2009). Bartl argues the only energy use required in reuse is the energy needed to reacquire and sort clothing from the consumers, which accounts for roughly 6 GJ (2008). Bartle predicts close to 200 GJ can be saved by reusing clothing (2008). Research conducted in 2009 found recycling of cotton T-shirts had less environmental savings than those provided by the reuse of the product (Farrant, Olsen, and Wangel, 2009). There are examples of reuse in the footwear industry as well. In a 2007 paper by Rahimifard, Staikos, and Coats, a list of pros and cons were developed for the reuse of footwear. The pros included extending the life of shoes, establishing collection methods, and job creation in developing countries. The cons proposed include carbon offsets resulting in transportation, moving waste from the developed world to the less-developed world, and economic impacts impacting the local footwear industry (2007).

In some cases even manufacturers and retailers are encouraging consumers to donate used clothing to secondary markets. Marks & Spencer, a large UK based retailer, teams up with Oxfam Clothes Exchange and offers a voucher for £5 off a £35 purchase at M&S when you donate a M&S labeled item to Oxfam (Marks & Spencer: Plan A- Partnerships). This program began in 2008 as a part of Marks & Spencer’s 100 Plan A environmental and social commitments (Marks & Spencer case study, DEFRA).

Some examples of reuse have taken on a worthy cause as well. Dress for Success is a London based not-for-profit which provides professional attire for women. Women must be referred to Dress for Success by a partner organization (e.g. job placement organizations, prisons, and homeless shelters). Dress for Success accepts donations from individuals and corporations, and clothing deemed not appropriate or un-wearable is donated to other charity shops, or sent to textile recyclers.

This way, no clothing item is sent directly to the landfill (Dress for Success Case Study, Centre for Remanufacturing & Reuse, n.d.).

Repurposing

Repurposing in the textile and apparel industry generally refers taking a textile or apparel product and modifying it for reuse, either as it was intended to be used, or for a new function. “Refashion as a process intercepts discarded clothing, reclaims, re-cuts and refashions, returning the item to the clothing stream, effectively creating a new loop and postponing its grave ending” (Fraser, 2009). Global trade has led to clothing and textile products with an increased carbon footprint and use of natural resources as product components often travel from multiple sites of origin to the final consumer. Refashioning existing products may be the most eco-friendly option for textile and apparel recycling, as the raw materials already exist and have already been processed (Dirksen, 2008 as cited by Fraser, 2009). Further, if consumers refashion their own goods, no costs will be incurred in collecting or sorting used clothing as it would be for resale. Traditionally, remanufacturing or repurposing has long been practiced in industries other than the apparel industry. The automotive industry has long been collecting used parts, cleaning and/or fixing them, and reusing them in other automobiles. This may be due to the high cost and value of a product, such as an automobile, and also the common occurrence of one component failing before other components, often when there is still significant value left in the product (Seitz & Peattie, 2004). Consumers seem to be partial to the idea of repurposing and repairing goods before purchasing new products. In a study done in 2001, 70% of consumers reported ‘always’ or ‘usually’ trying to repair items (Barr et. al. 2001, as cited by Watson, 2008). Carpeting has been studied for effective use in remanufacturing. Because carpet is generally nylon, which is a fiber able to withstand remanufacturing processes, specifically cleaning and reprinting, it may be an ideal produce segment for remanufacturing (Resource Recovery Forum, 2006). Currently the remanufacturing of carpets is relatively low, and the backing generally does not allow for processing, and it is only available for carpet tiles (Resource Recovery Forum, 2006). Footwear repair has been a traditional practice, and still exists although not at the degree it once did. There are 1500 cobblers in the UK (Rahimifard, Staikos, and Coates, 2007), and many brands offer repair services as well. Church & Co, who produce hand-made shoes receives up to 18,000 pairs of shoes to be repaired and returned annually (Rahimifard, Staikos, and Coates, 2007).

Marginal Value of Time (MVT)

Marginal value of time (MVT) can be defined as the remaining value of a product after a certain period of use. Some researchers argue that MVT may affect the probability of a product being returned to the manufacturer for resale to a secondary market. Only if a product has significant value left is it worth the transaction cost occurred during reverse logistics and reprocessing for resale to a secondary market. Most research on closed-loop systems occurs when products have a significant amount of value left after use, such as the automotive industry, as well as the electronics industry. Other research highlights products which have a very small life cycle, where product acquisition can occur almost immediately, such as packaging. Morana et al. formed a two by two matrix to depict the likelihood of product reacquisition based off of the interaction between use phase and marginal value of time. They propose that high quality apparel exists in the quadrant where the use phase is long, and the MVT is low. The return rates for products with a longer use phase are hard to predict. Electronics, which have high MVT and generally short use phases have frequent collections, while packaging has both low MVT and a short use phase, and may have immediate collection. Products with significantly high MVT and long use phases may have a very specific route of return, such as automobiles. The product characteristics of high quality apparel (longer use phases, and low MVT) make acquisition difficult. Morana et al. argues that MVT influences the likelihood of consumers to dispose of their products in certain manners. Low MVT reduces the likelihood consumers will return a product, as well as reducing the motivation producers have to encourage consumers to return their products.

Products with high MVT may also influence design. Modular design may become important, as it allows products to be reused, remanufactured, or repaired for a secondary market. Because the reverse supply chain for returned products exists as separate entities coordinating product movement, significant transaction costs can occur. As well as transaction costs for firms, consumers may also have transaction costs when disposing of a product. Morana et al. proposes that consumers generally have three disposition options pertaining to clothing. They may send apparel and textile items to the landfill, they may recycle them through private and government organizations, or they may sell them to another consumer. The transaction costs for consumers differ depending upon which disposition option they choose. When sending an item to the landfill consumers have virtually no transaction costs other than the guilt associated with not pursuing more environmentally sound options. Transaction costs associated with donating clothing to municipalities or private recycling organizations usually only occur to the firm taking back post-consumer clothing in the form of planning and logistics costs. Secondary sales to other consumers, either through consumer to consumer venues or consignment options carry transaction costs in terms of storing goods, collecting information on firms through which consumers can resell goods, transportation, and the risk associated with goods not selling. A closed-loop supply chain for textile and apparel firms represent a potential fourth option, and may come with its own set of transaction costs. Morana et al. found that most take-back initiatives for apparel were either temporary, or used as a marketing initiative to promote new sales of products. Morana et al. conducted a case study on ECOLOG, a network of European manufacturers, retailers, consumers, and recyclers who represent apparel items which can be completely recycled. The ECOLOG network represents both the forward and reverse flow of the supply chain, and only works with polyester products. All components of a product with an ECOLOG label must be homogenous (zippers, fabric, thread etc.). ECOLOG products are all fully recycled back into virgin materials for new product production. Take back procedures for ECOLOG products differ depending upon consumers. Consumers are generally either private consumers, or companies. Private consumers, who usually own one or two ECOLOG pieces either, return products directly by mail, or indirectly through a participating retailer. Companies, who may provide employees with uniforms, may either return products by mail, or if the volume is large enough, a collection option will be provided by ECOLOG. As is common with most closed-loop systems, even though numerous products had been designed and sold, virtually none were returned for recycling. When examined, it was found that retailers either did not know about, or encourage consumers to return ECOLOG products. Most consumers interviewed by Morana et al. did know about the return options, but preferred to donate the clothing to charity, or discard of them with other apparel. Morana et al. found that companies also preferred to donate the ECOLOG clothing to charity, even though there were simple take back measures put into place by the ECOLOG network. Transaction costs bared by the retailer of storing and forwarding used apparel back to the manufacturer diminished the incentive to take back used apparel. Morana et al. proposed that there must be an incentive put into place for consumers and retailers to participate in a successful closed-loop system. Deposits or a monetary incentive may influence consumer's participation (Morana et al., 2007).

Reacquiring Consumer Textiles

The first step in any form of textile recycling is to reacquire goods from consumers. In many cases this proves to be the largest barrier to any successful recycling system, as obtaining goods from consumers can be unpredictable. There are a variety of ways which firms can reacquire textiles, including curbside collection, donation centers, drop boxes, door-to-door collections, retailer programs, and direct mail. Each of these methods varies from community to community, and each has individual transaction costs, both for municipalities, as well as consumers. There may also be differentiation between countries, both in the amount of textiles collected, and in the treatment of those items once collected. In a UK based study done by Woolridge in 2006, it was found that for the year 2000-2001, 16,871 tons of materials were collected, generally by door-to-door collection or bring banks, where multiple materials may be disposed of in a recycling center. Of that 16,871 tons collected, 15,576 tons were reused, and 1,295 tons were discarded as waste. Bring-banks generated the most amount of clothing to be recycled, 12,328 tons, and 95% of the time these drops were done concurrently with other goods (Woolridge, 2006).

Researchers have increasingly concentrated on closed-loop supply chain management because of the importance of planned and unplanned product returns, as well as the rise in legislation requiring producer responsibility take-back, particularly in the European Union. Little research has looked at the key issues surrounding establishing effective closed-loop systems, particularly methods of acquiring products at the end-of-life stage. Products may be returned at various stages of their lifecycles. There are specific examples where product returns overwhelm the profit derived from products sold, such as the mail-order business. Many companies believe that product returns are out of their direct control. The Salvation Army has 4,400 clothing banks in the UK alone, which accepts textile items, shoes, handbags, belts and more. The Salvation Army also conducts a door-to-door service where they deliver bags to households, and collect them a few days later (Salvation Army Trading Company, Ltd). Many studies have been done on consumption behavior, and few have also been conducted on disposal methods. In order to design textile and apparel items to be less likely to be disposed of as waste, it may be necessary to study why and how consumers dispose of their textile and apparel products. There are many potential reasons for consumers to dispose of their apparel products before the end of their useful lives, and Sproles in his 1981 essay suggests the leading causes to be market saturation, consumer’s boredom with fashion trends, consumers desire to be unique, designed obsolescence by industry, and changes in social trends (Sproles, 1981). Methods for disposition may also have a variety of motivations. A study done in 1995 by Pitts found that recycling behavior was related to income, where people who earned more than $30,000 cited fashion issues as the reason for disposal, and lower income subjects cited fit as the reason for disposal (Pitts, 1995 as cited by Koch and Domina, 1997). There has been more research concentration of methods for disposing of textile and apparel, and largely research has been lacking in reasons for clothing disposal. Those studies done have largely been focused on college aged students (Shim, 1995; Koch and Domina, 1997) and found that fit was the most cited reason for disposal. There were varying methods of disposal, donating to family and friends or charitable organizations being the most common, and both studies found women to be more concerned with the environmental implications of disposal. In a 1999 study done by Koch and Domina it was found that curbside collection significantly increased consumer's likelihood to recycle materials, supporting the relationship of ease and probability of recycling (Koch & Domina, 1999). Researchers found that consumers disposed of textiles biannually, which they related to the minimal cost of storing apparel items, and the time and energy costs associated with recycling unwanted goods. Koch and Domina also found that the least common forms of recycling were consignment and restructuring for reuse (Koch and Domina, 1999). It was found that respondents were more motivated by the emotional values of helping the needy and not creating waste than of recapturing the original cost of the garment (Koch and Domina, 1999).

Perceived Value of Consumer Products

It is difficult to define and measure consumers perceived value. Ulaga & Chacour propose that customer-perceived value is made up of two components: customer perceived quality and customer satisfaction (2001). Value is a relative term, which is often constructed of many different components. Most researchers agree that value in some way is represented as a trade-off between some sort of benefit and sacrifice (Woodruff, 1997; Ulaga & Chacour, 2001). Although there is a set of functional needs for a garment, such as providing shelter, which constitutes an important part of overall perceived value, there is also another, less tangible set of characteristics which consumers value. Sociological and psychological needs are also components of value for consumers. Research has shown that possessions tend to take on a deeper meaning than just satisfying a need. Possessions may become extensions of ourselves or represent the development of a consumer identity (Belk, 1988).

It is difficult to understand what constructs make up perceived value in the consumers mind. Value may be related to extrinsic, intrinsic, psychological meanings, or simply utilitarian functions. Higher priced apparel can often be perceived by the consumer as also higher quality items (Niinimaski, 2009). Consumers may be more interested in undertaking actions which prolong the life of a garment if a high price was paid for the item, including making small repairs, better maintenance of clothing, and reuse or recycling at the end of the products useful life (Niinimaski, 2009). Consumption can be influenced by personal values, and what people consume and deem significant speak to the relationship between the meanings attached to products and the consumers personal values (Richins, 1994). Richins hypothesizes that possessions can take on two types of meanings: public and private. Public meaning can be composed of society's influence on consumption, and also as an expression of consumers self to society. Private meaning is composed of both public meaning, but also of the attachment a consumer has with a product over time (Richins, 1994). A product may take on very different meanings and perceived value for different consumers. Studies done on the importance of material possessions to consumers has traditionally segmented consumers into two segments: materialists and non-materialists (Richins, 1994). Research suggests that materialists and non-materialists will value products for different reasons. Materialists value products which are consumed in public, and are representative of exclusivity. The determinant of exclusivity may be related to a higher price, and are less likely to be sentimentally important. Non-materialists, in contrast, are likely to place a high value on goods which are of significant emotional or psychological importance, and may not reflect prestige (Richins, 1994). This information can be useful in determining design requirements for products which have high value for consumers, and how those design requirements may differ from products which have lower perceived value for consumers. It may be reasonable to assume that products which consumers place higher value upon, may need to be designed for longevity. If a product is to be of higher value for a consumer and its life span elongated, the environmental impacts of its production and consumption may less important. Therefore, different materials and production methods may be more suitable for high-valued products than those for low value products. If it can be assumed that low value products may be consumed and disposed of more rapidly, than the environmental impacts of its production and disposal may be very important. It may be more important to produce low value products with eco-and environmentally friendly and efficient materials and processes. A scale may be devised which compares perceived consumer value of goods, and their intended product life span. At the top of this scale may be goods which have very high perceived value for consumers, such as heirloom pieces or goods with significant emotional value. These goods may be intergenerational, or intended to be kept and maintained for a very long time. At the opposite end may be goods which have very little perceived value for consumers, and may in turn be considered disposable by consumers.

Swinker and Hines (2006) examined indicators which consumers use when evaluating clothing quality and their expectations of high-quality apparel. The top five characteristics consumers noted as important were a style which complemented their figure, cost, fashionable, color, and fabric hand. Garment longevity was listed tenth. Most indicators were found to be aesthetic except for cost. Although previous research had indicated that cost was strongly associated with quality, Swinker and Hines (2006) found that when surveyed, consumers disagreed that higher-cost garments were also of higher-quality. Swinker and Hines hypothesize that although cost was an important quality indicator for consumers, this may be because they are not able to differentiate the quality assessment of a garment from the motivations in the purchase decision process (2006). More than half of respondents listed quality as important in their purchase decision. Of those who listed quality as important, their top 6 quality indicators were both intrinsic as well as performance based. Construction, fabric, notions, fabrics ability to hold shape, not pill, and not wrinkle were all important indicators of quality (Swinker & Hines, 2006). Results indicating that quality is not of importance to more than a third of buyers may indicate that consumers are not primarily concerned with the longevity of their products, and will not be likely to consider long lasting garments of high value.

Product Lifespan

Trends and fads in fashion result in short life cycles, more products, and often more waste. The concept of fashion itself is not a sustainable one, as fashion calls for constant change, and constant change calls for more products (Niinmaki, 2009; Hawley, 2006). A study of Finnish consumers found that on average a piece of clothing is kept for almost three and a half years (Niinmaki, 2009; Fletcher, 2008). Increasing the lifespan of a product is an accepted concept of sustainability. The concepts of dematerialization, eco-efficiency, and eco-sufficiency are current sustainable initiatives and are intended to gain more utility for goods and processes. Increasing the life span of products can limit overall consumption, and help to reduce energy use and waste creation, which may be especially important when inputs are not renewable. Although efficiency in manufacturing and resource productivity has been thoroughly researched as possible sustainable measures, little research has been done on ways to increase the lifespan or utility of a product to limit overall consumption and waste. Research has proposed that a combination of eco-efficiency and eco-sufficiency is necessary for sustainable development. In 2005, Cooper developed a model in which both efficiency and sufficiency were drivers for different sustainable outcomes. In the model pure efficiency led to eco-efficiency, which alone lead to ‘green growth’. Cooper posits that green growth alone will not be effective if consumption continues to grow at a steady rate. Conversely, Cooper proposes that sufficiency, which will be realized in slow consumption, or the reduced output of products and services, if utilized alone will result in recession, limiting jobs and economic prosperity.

A combination of both efficiency and sufficiency, which can be realized by increasing product life spans, results in sustainable consumption (Cooper, 2005).

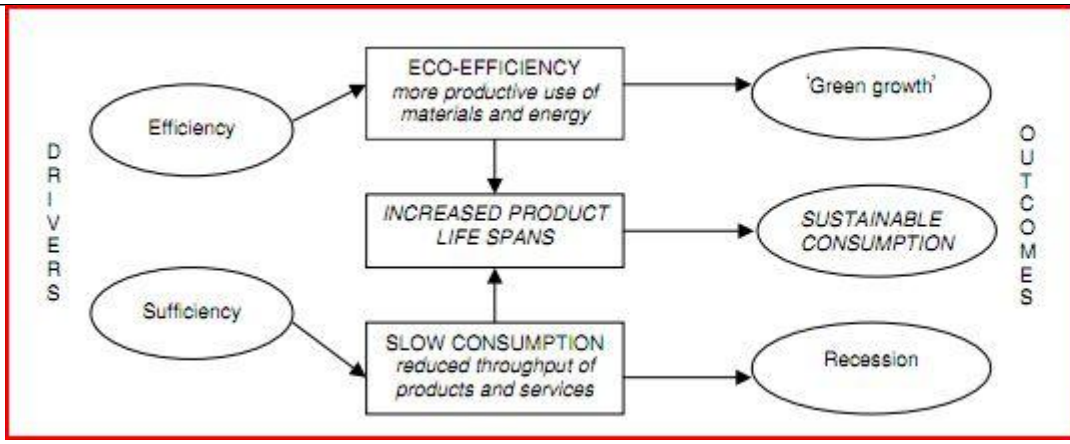

Figure 8: Product life spans and sustainable consumption, Cooper, 2005

Cooper hypothesizes that increasing product life span will limit material inputs, and can also increase jobs as 'skilled, craft based production methods and increased repair and maintenance work would provide employment opportunities to offset the effect of reduced demand for new products" (Slower Consumption, 2005). Some consumers and designers have utilized concepts of eco-efficiency and eco-sufficiency by creating products and systems of consumption based on principles of increased utilization and decreased overall consumption. This movement has been dubbed the 'slow fashion movement'. Slow fashion items are generally of higher quality, built to last, and processed in the most sustainable way in terms of social responsibility, waste and energy reduction (Niinimaski, 2009). The Eco-Index also provides guidelines for designing products for durability and longevity. Use of appropriate materials, construction methods, finishes, designs are recommended, as well as designing processes for multiple uses (2010). The eco-index also recommends durability testing done by a third party. The Eco-Index also gives guidelines for designing products to be repaired or upgraded, including selecting material which are able to be repaired or replaced, and offering such service, as well as maximizing the number of features which can be repaired or upgraded (Eco Index, 2010). Some companies already offer repair options. Patagonia offers a repair service for their products. Consumers may ship their product to Patagonia, who will then determine if the product can be repaired, and if there are any associated costs for the repairs. If Patagonia determines that the product cannot be repaired, they may offer a replacement product or gift certificate for the last known value of the product, at their discretion (Patagonia, n.d.). Repairing products has been a long standing tradition, as many apparel and footwear products were traditionally repaired rather than replace. In the past cobblers often resoled footwear to extend the products life. Consumers often were capable of performing small repairs on items, such as patching holes and mending items. Research has indicated that repairs made by consumers are less driven by economic factors, and mainly related to consumer's lifestyle choices (Fletcher, 2008).

Research conducted on increasing product longevity performed by the Eternally Yours Foundation provided three findings to increase the lifespan of a product

i) Material quality and detail have great impacts on what consumers choose to keep for longer period of times. Designs that transcend trends are necessary to increase products lifespan

ii) Designing products to have multiple lives or uses creates the opportunity for products to be used longer in different ways. "Designing with scenario works on two levels; one to allow multiple uses over a long period of time, and another to foster connection and attachment to objects that might counteract a desire to replace it someday

iii) Providing service of upgrade and repair results in products which are designed to last longer (Belletire, Pierre, White, 2007).

Sustainability and the new product development process

Opportunities

Integrating sustainability concepts into the new product development has initiated from a variety of factors. Affordability of products made possible by mass production has lead to unsustainable consumption habits (Niinimaki, 2009). Unsustainable consumption habits may lead to a rise in natural resource and energy use as well as waste creation. The concept of fashion in general is not a sustainable notion (Niinmaki, 2009; Hawley, 2006). Fashion calls for constant change, while sustainable principles generally call for maximizing the utility of what you currently have as well as using less overall. The current state of consumption and production provides a lot of opportunity for integrating sustainability principles into the new textile and apparel process. The rise in awareness and demand for sustainably made products from consumers, tightening of governmental regulations and industry standards, and the decrease in availability of raw materials may all provide initiatives for sustainable new product development practices. Some research has shown that lower cost is often the primary driver for integrating sustainability into your organization, which is impacted by the cost of resources needed (O'Neil, 2010).

Consumer research reports indicate that consumers are more interested in ethically manufactured goods. In a 2009 survey based on Finish consumers, it was found that 91 percent of consumers reported being at least somewhat interested, if not extremely interested in ethical consumption and a products' environmental impact (Niinmaki, 2009). There is currently an emerging demographic of consumers who are interested in sustainable textile products. Researchers have found that markets who tend to be more environmentally conscious are more educated, high income, and often female (Thiry, 2005; Niinmaki, 2009). The female dominance of this market may lead to opportunities in womenswear and children's products, as well as other products for which women are the primary buyers (Thiry, 2005). Some researchers have named this market of consumers LOHAS, which are those with Lifestyles of Health and Sustainability, which demographic is estimated to be 45 million people in the US, and growing (Thiry, 2005; Moore & Wentz, 2009). The market and opportunity for sustainable products will likely to continue to grow as consumers become more interested and educated and then begin to demand transparent and sustainably driven products. A 2010 report published by the Retail Strategies Research report, ‘green’ and sustainable initiatives showed that “green” stems from a variety of sources. 52% of the firms surveyed cited consumers as one of the main initiating factors. Other initiating factors included supply chain partners, government and regulatory agencies, brand value, board of directors, as well as internal leadership. The report showed an increase in influence in most categories from 2009 to 2010, with the exception of consumers, board of directors (which showed no change), as well as logistics providers. In a 2009 study conducted by Niinmaki on ethical consumer behavior, 65.9% reported ethicality, product safety and environmental impacts of textile and clothing as important considerations when purchasing products (Niinmaki, 2009).

Rising government regulations and industry standards may also provide an opportunity for sustainable product development. “Tightening chemical regulations in Europe over the last few years, such as the EU Chemicals Directive, has impact on both the European textile industry and on merchants attempting to import textile products into Europe” (Thiry, 2005). Decreasing space in the landfill may also lead to increasing fines to dispose of waste, which may drive up costs for many firms. Companies may become more interested in sustainably designed processes and value reclamation processes. Availability of raw materials, such as oil needed to produce polyester and other synthetic fibers, or water needed intensely in the growth of cotton, may also provide an opportunity for innovation in new product development “It takes 800 liters of water to make just one t-shirt" (Salvation Army Trading Company LTD, n.d). As the availability of fresh water decreases, organizations may have to develop fibers, systems, or processes which are less water intensive.

Some market segments, product categories, and distribution channels represent more significant opportunity for impact for sustainable products. Children's products may offer opportunities for sustainable product design, and they represent almost one third of the US market (AAFA Data, 2010). Children's wear can easily be reused, as there is usually significant value left in the product after a consumer may dispose of the garment. Corporate clothing and the carpet industry also offer interesting opportunities for sustainable product design and development. Corporate clothing represents almost 10,000 tons of waste sent to the landfill each year in the UK alone (Company Clothing Market Research Report 6th edition, as cited by Centre for Remanufacturing & Reuse, 2009). Corporate clothing enables easy reacquisition of textile and apparel products, which have been shown to limit the effectiveness of textile recycling and reuse programs (Guide, Harrison, Wassenhove, 2003). Research conducted by the Centre for Remanufacturing and Reuse in 2009 indicated that large logos and emblems can be costly to remove and limit potential for garments to be reused (2009). Carpet may also be easy to reacquire from consumers, and can potentially be designed for easy recycling (Boswell, 2010).

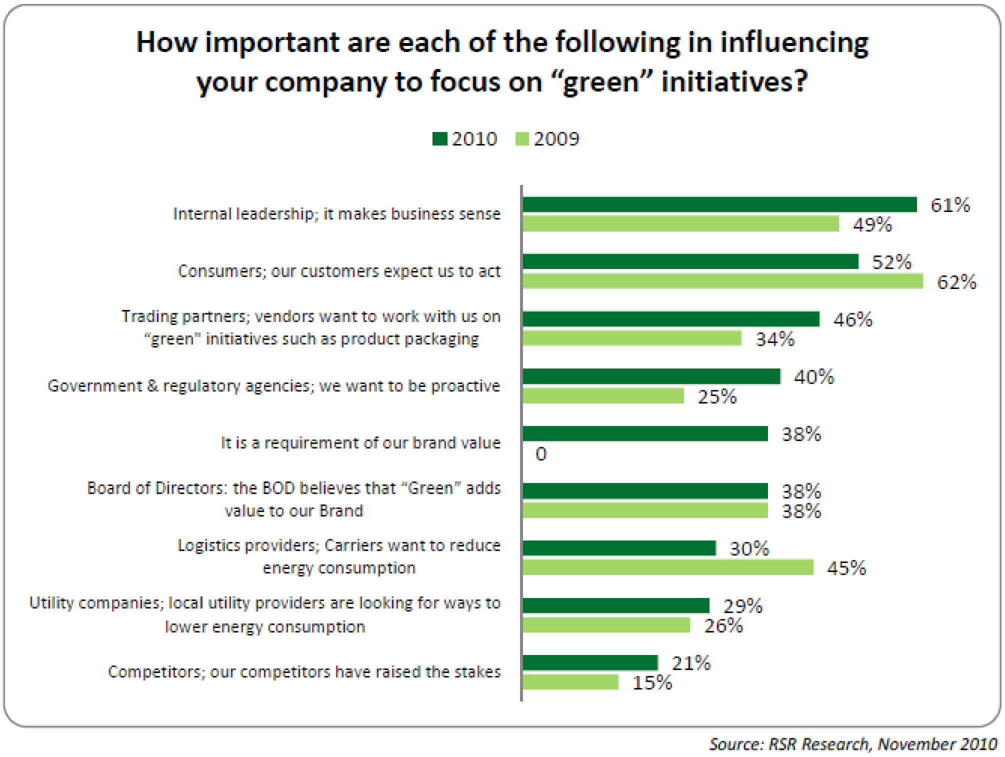

Figure 9: 'Green' initiatives, RSR Research, 2010

Design

Research indicates that eco-design is composed of seven considerations: selecting low impact materials, reducing volumes of materials needed, cleaner manufacturing, minimizing waste and energy use, minimizing negative environmental impacts during use, extending the products lifespan, and designing for reuse, recycling, remanufacturing at the end of products life (Roy, 2000). The Industrial Designers Society of America outlines various stakeholder needs to be considered during ecological design. Four stakeholder categories are identified: the environment, the user, society, and the client. The environment refers to all elements which comprise the biosphere, and indicates that designers should create products which reduce environmental impacts and communicate the environmental benefits of a design. The user refers to the person or group of people which will interact with a product during its useful life. Taking user needs into consideration at every level of the design stage produces needed and desired products which effectively meet consumer's needs. Society refers to all people who are directly or indirectly affected by the product. Finally, the client refers to the entity which requires the product, system, or service (Belletire, Pierre, & White, 2007). Designers can enable products to be designed with more sustainable practices, including advancement in eco-efficiency, which generally refers to a product's input utilization being maximized, as well as eco-sufficiency, or dematerialization, which refers to increasing the benefits from fewer goods and services (Cooper, 2005; Carley & Spapens, 1998 as cited by Niinimaki, 2009). Sustainable design indicators can include integrating sustainability into the selection of materials, production processing, packaging, product structure and ease of disassembly, sustainable use, and disposal. Designers may have large control over product impacts through material choice and product structure. Product structure can influence environmental impacts in determining what types of materials will be needed, both textile and non-textile components, and thus production and processing steps. Well informed material choices allow waste minimization and energy efficiency during processing, use, and end-of-life. Currently material selection is not based on life-cycle analysis and environmental impacts. Often, fast fashion goods intended for use in only one or two seasons are designed with materials which may take years to decompose, if they decompose at all (Earley, 2006 as cited by Fraser, 2009). The selection of material also has strong influence upon what can happen to the product at its end-of-life. Gulich developed a model to compare the ease of recycling to the variation in materials used, and posits that single-material systems are most suitable for recycling. Single material systems consist of a single material, where no composites are used. The recycling of single material systems is preferable because it requires no separation, and can be recycled back into a pure single material. Single-material systems may not be feasible when materials are expensive, specialized, or the functionality of the product calls for multiple materials. Gulich defines single-material composite systems as those products which are made from the same polymers, such as polypropylene fiber coated with polypropylene finishes. Gulich proposes that these single material composites are also easy to recycle. Products with multiple materials can be difficult to recycle, and if possible, redesigning multiple material composite systems to be single-material composite systems is ideal. If multi-material composites are permanently fixed to one another, recycling becomes difficult and generating energy by incineration may be the best and only form of recycling.

Examples of the integration of sustainability into the new product development vary in execution and effectiveness. In a 2004 study by Young, Jirousek, and Ashdown, post-consumer clothing was reconstructed into fashion forward goods for a target market of urban nomads. The Researchers created a line which satisfied their functional needs, and also recycled post-consumer clothing and fabrics into new products. Urban nomads in this study were defined as ‘young professionals living in urban areas who commute using ecologically sensitive public and human-powered modes of transportation (Young, Jisrousek, and Ashdown, 2005). Following an analysis of the target market needs, researchers designed and produced numerous products in various sizes, and displayed them in a mock store set up to obtain feedback from consumers. The products were tested by being displayed in a set-up which resembled a normal retail store environment, in order to obtain information about not only the products, but the intended marketing presentation as well. The merchandising scheme communicated the benefits of using post-consumer goods as raw materials from the environmental perspective, and also allowed consumers to feel and try on the products. The testers gave feedback in terms of a silent auction, in which they indicated how much money they would be willing to pay for a product with these benefits, which allowed researchers to obtain information concerning a pricing structure and value analysis for the products. A questionnaire provided feedback on the attitudes and opinions toward the clothing.

To identify an opportunity in the market, researchers shopped the second-hand market to see what garments were in abundance. They found that jeans, t-shirts, sweatshirts, button-down collar shirts, sweaters, and men's suits were readily available. There were many inherent qualities of these particular post-consumer goods which made them ideal for use in restructured apparel items such as sturdiness, quality fabric, useable fabric amounts due to consistency in shape, warmth, texture, and comfort. During the design stage, researchers found that the new product design was dependent upon the materials used, similar to designing with animal hides (Young, Jirousek, and Ashdown, 2005). Designers did use other materials which were not directly sourced from post-consumer traders, including new fabrics which were made from postconsumer recycled materials, waster-resistant lightweight rip-stop nylon, separating zippers, reflective piping and metal D-rings. Designers had difficulty in grading patterns, due to irregular shapes of materials used, and as a result there were variations in each piece. There were also challenges in cleaning the post-consumer apparel. Denim, T-shirts, and sweatshirts were simply washed before deconstruction. Suiting and finer material was deconstructed first, made into a new garment, and then dry-cleaned. During production, each pattern piece was cut by hand and then sewn in a linear 'assembly line' process. After extensive questioning it was found that respondents valued the distinctiveness of the apparel, and even those who would not normally wear second-hand clothing found the garments appealing. The respondents liked the environmental appeal, but functionality and good design were superior in the mind of the consumers. Researchers also found that there was a potential to increase the value of the clothing by using garments which had a significant emotional appeal for the consumers, such as their grandfathers suit. This added value potential opens opportunity for custom markets, as well as mass markets. Researchers proposed a three-tier system in order to maximize the potential for using post-consumer clothing as an input material in new product development. The first tier capitalizes on new fabrics made with less environmentally negative effects, such as organic cotton or recycled fleece. This allows for easier production, and may enable low-cost goods. The second tier would be deconstructed ready-to-wear, and would be produced similar to the methods described in their research. New garments would be produced using post-consumer apparel pieces as raw materials. These garments would likely be a higher cost good, as production may be labor and time intensive. The third tier would include commissioned reconstructions, and would include the value-added pieces discussed earlier. Consumers would supply raw materials which had a significant emotional value to them, and designers would reconstruct them into something which was wearable and stylish, either through pre-developed patterns, or customized patterns. These pieces would likely fall into a premium price tier, as the labor and time involved would be significant (Young, Jirousek, Ashdown, 2005).

In 2010 the apparel industry retailed over 19 million garments. Men's wear accounted for 24.4% of the total units sold, women's wear representing 44.4%, and children's wear representing 31.2%. The largest product categories sold by unit were hosiery (3.9 million), intimate apparel (1.9 million), and male underwear (1.5 million). Other significant categories included tops and bottoms (5.6 million and 2.7 million respectively). The largest channel of distribution by unit volume was mass merchants who accounted for 7.9 million units. Specialty stores accounted for the second largest unit volume, and national chains represented the third (4.1 million and 2.3 million respectively) (AAFA, 2010). Some customer categories, product categories, and distribution channels represent better opportunity for impact than others. Children's wear, which represents almost a third of the total market, may be ideal for reuse, while it is more challenging to reuse intimate apparel. Hosiery, which accounted for the largest product category by unit volume and generally has a short lifespan, may represent a very viable product for recycling. Initially concentrating efforts in areas which may prove to have the largest effects will be important to ensure a meaningful, significant impact. A particular market segment which has been studied as having high potential for success for textile and apparel reuse or restructuring is the corporate clothing sector. Corporate clothing represented 10,000 tons of waste sent to the landfill in the UK (Center for Remanufacturing and Reuse case study, DEFRA). When research was conducted, it was found that large logos and emblems which can be costly to remove limited the potential for garments to be reused (Center for Remanufacturing and Reuse case study, DEFRA).

Sustainability for textile and apparel design has not yet been developed as a cohesive practice. A proactive attempt at sustainability in one area of product development may have adverse effects in another area (Roy, 2000). In the 1990's designers began to take a comprehensive approach to designing for the environment, considering the product at all segments of its lifecycle. Although designing products with eco-design tenants in considerations will decrease the negative environmental impacts of products, alone they will not be enough to account for the continued growing population, particularly in areas experiencing rapid growth (Roy, 2000). Because eco-design alone will not be sufficient, different forms of design and concepts of ownership have been developed. When manufacturers lease products and retain ownership it provides incentive to produce higher quality goods as they will be reacquiring the product after use by consumers. Consumers may be more interested in the service or utility provided by the product and research has found that ownership may not be important.

Currently eco-efficiency in the forward moving linear process focuses on minimizing volume and negative outputs of production. Eco-effectiveness, a term developed by the McDonough Braungart Design Chemistry to describe a strategy for designing a human industry that is safe, profitable and regenerative, producing economic, environmental and social value, as opposed to eco-efficiency. Eco-efficiency is described as a strategy of minimizing harm to natural systems by reducing the amount of waste and pollution human activities generate. Eco-effectiveness produces cyclical oriented materials made to hold their value over time (McDonough Braungart Design Chemistry, n.d.). Rather than eliminating waste, eco-effectiveness works towards retaining value over numerous life-cycles. Eco-effectiveness is design and materials oriented, and does not generally minimize or prolong a products life. Eco-efficiency strategies either try to minimize the materials needed, or maximize the time until they become waste. Eco-efficiency only prolongs a products life, but does not work to maintain the value of the material as a resource. Eco-efficiency aims at making negative environmental impacts decrease over time, but does not eliminate them from the design. Efficiency levels can be misleading when compared to the increase in production volume over the same time period (McDonough & Braungart, 2002). When materials are mixed during recycling, as is often the case, they may not be able to be easily recycled again. Often, rather than recycling, we see down cycling, with a significant decrease in the value and quality of a product. Recycling efforts may also produce more environmentally negative off puts than original production from virgin materials. Minimizing input materials is not a long-term solution because it does not allow for creative re-design and limits growth, which would call for more materials. Braungart and McDonough base their cyclical approach off of nature. In nature, the concept of waste is eliminated, as all outputs from one process become inputs for another (Braungart & McDonough, 2002). If waste from processes became inputs, either technical or biological, than the fact that they are not utilized in the product is not as important. Efficiency and effectiveness can work together in doing the 'right' things in the 'right' ways, but increasing efficiency alone, which often industries goal, will not be enough. "If industry is driven by systems that are inherently destructive, making them more efficient will not solve the problem" (Braungart & McDonough, 2002). The alternatives for products of consumption are products of service, which are designed as technical nutrients made to retain value through many lifecycles and remain as property of the manufacturer. Interface Inc. tried to put this into practice through leasing of commercial carpets (Quinn, 2003)

Fletcher et. al. posit that most sustainable design can fall into three categories: product focused, results focused, and needs focused. Design for sustainability which emphasizes a product focus tries to make current products more systematic. Fletcher et. al. proposes that there is much research being done in this particular area on the capability of improving designs and methodologies to measure efficiency (2001). Design for sustainability which is results focused examines ways to redesign how clothing is "distributed, organized, and used" (Fletcher et. al, 2001). Fletcher et. al. suggest disposable clothing could have significant implications on the environmental impact of laundering clothing, although the adoption of disposable clothing by consumers may not be realistic (2001). Disposable clothing challenges conventional assumptions about sustainability, although if designed using materials which could be easily recycled or biodegrade, it may be ideal for products which do not have significant importance or value in the consumers mind. Products which are designed to be needs focused redesign products in order to satisfy consumer's needs in different ways. Researchers pose that most human needs fall into two basic categories: functional and psychological, both which can be met in a variety of ways (Fletcher et. al., 2001).

Many design programs have been developed to integrate sustainability into the product design stage. Design for the Environment (DfE), includes environmental concerns into the design of products, processes, and management systems (Sroufe, 2000). Specific DfE models have been developed and made available to practitioners. While it appears that much progress has been made in developing these models, they have not been integrated with one another to create a system that allows for assessment of overall DfE performance and the trade-offs therein. Designing with the environment in mind now calls for the integration of environmental factors into all stages of the NPD process. There are many more stakeholders to consider in sustainable design, such as Non-Governmental Organizations, Governmental Organizations (such as the EPA), and the global community at large. In the early stages of NPD, meeting the needs of the stakeholders "such as regulators" is important, while in the later stages of NPD, working with special interest groups and third-party endorsement of products becomes more important (Sroufe, 2000). Office furniture manufacturer, Herman Miller, developed a design for the environment program in the 1990’s in attempts to meet cradle-to-cradle design requirements. Herman Miller has had a history of being an Environmental steward since the early 1950’s, and saw an opportunity to increase their pro-environmental efforts in cradle-to-cradle design. Herman Miller challenged not only their current design process in attaining cradle-to-cradle design, but also hoped to establish different metrics to measure their environmental efforts with. Herman Miller worked closely with MBDC to develop tools with which to evaluate and measure the progress made from Herman Miller towards successful design of cradle-to-cradle products. With the guidance of MBDC, Herman Miller was able to certify 9 products, all with Silver or Gold level certifications (McDonough Braungart Design Chemistry, n.d.). There are obvious advantages of using tools to measure environmental progress, such as clear objectives and goals which help channel effective efforts to meet those ends. Unfortunately, if not conducted correctly much effort can be spent analyzing and defending the chosen tool and its measurement process rather than the broad goal of achieving environmentally sound products and processes.

Aside from design considerations concerning product and fiber production and processing, many environmental and eco-design strategies are calling for designers to also consider how the product is to be used. Most of the research on redesigning for sustainability largely focusing on how things are consumed: consumed greener, consumed differently, and consumed appropriately (Fletcher et. al., 2001). Interface Inc., a leading provider of carpet tile, developed an environmental program, Evergreen™ Service Agreement, their answer to producer responsibility at products end-of-life, and their take on closed-loop systems for the carpet industry. Interface Inc., company chairman, Ray Anderson, developed the Evergreen™ Service Agreement based off of Paul Hawkins theory, “licensing products of service”, which was illustrated in Hawkins book *The Ecology of Commerce.* The theory posits that rather than the traditional business of selling goods from producer to retailer to consumer, firms could develop long-term leases with consumers, and reacquire goods after a specified period of time. Hawkins proposed that consumers are not necessarily interested in owning a product, as much as they desire the service provided by the product. Agreements between producer and consumer would be developed, and products could be licensed to consumers, but not thrown away or disposed of. Using this model, Interface Inc. developed a program where the consumer would pay a monthly fee, and Interface Inc. would install the carpet, maintain the carpet, replace tiles as needed, and remove the carpet at the end of its term. This agreement would allow Interface Inc. to build long-term agreements with their customers, steady returns, and help build in sustainable economic business practices. Despite what appeared to be a solid business plan, the Evergreen™ Service Agreement failed to take off in popularity among industry, with only 6 agreements being signed from the programs start in 1995. There are a variety of reasons cited by consumers for aversion of the program, many saying that it was too complex and confusing. There were also accounting issues for companies, many having difficulty moving funds into operating expenses in order to 'buy' a lease (Quinn, 2003).

Life Cycle Analysis Methodology

There are numerous methods in place to measure the environmental impacts of products, services, or companies. Belletire, St. Pierre, & White cite at least seven environmental impact assessment methods, including qualitative matrix LCA, Pharos, LiDS wheel, Ecological Footprinting, MBDC, Total Beauty, as well as Life Cycle Assessment (2007). Environmental assessment methods may vary in scope and technique, which makes some methods more appropriate for use than others. Belletire, St. Pierre, & White created a chart to visually map these methods (See Figure 6). Each method was mapped on a bi-axial chart, with a subjective-objective spectrum on one axis and comprehensive-incomplete spectrum on the other (2007). "Subjective methods yield different results, depending on who uses the method, while objective methods yield more consistently repeatable results. In this diagram, completeness is gauged by the degree to which a broad range of impact categories has been included (including subcategories within ecological health, human health, and resource depletion) as well as including all phases of the life of the product" (Belletire, St. Pierre, & White, 2007).

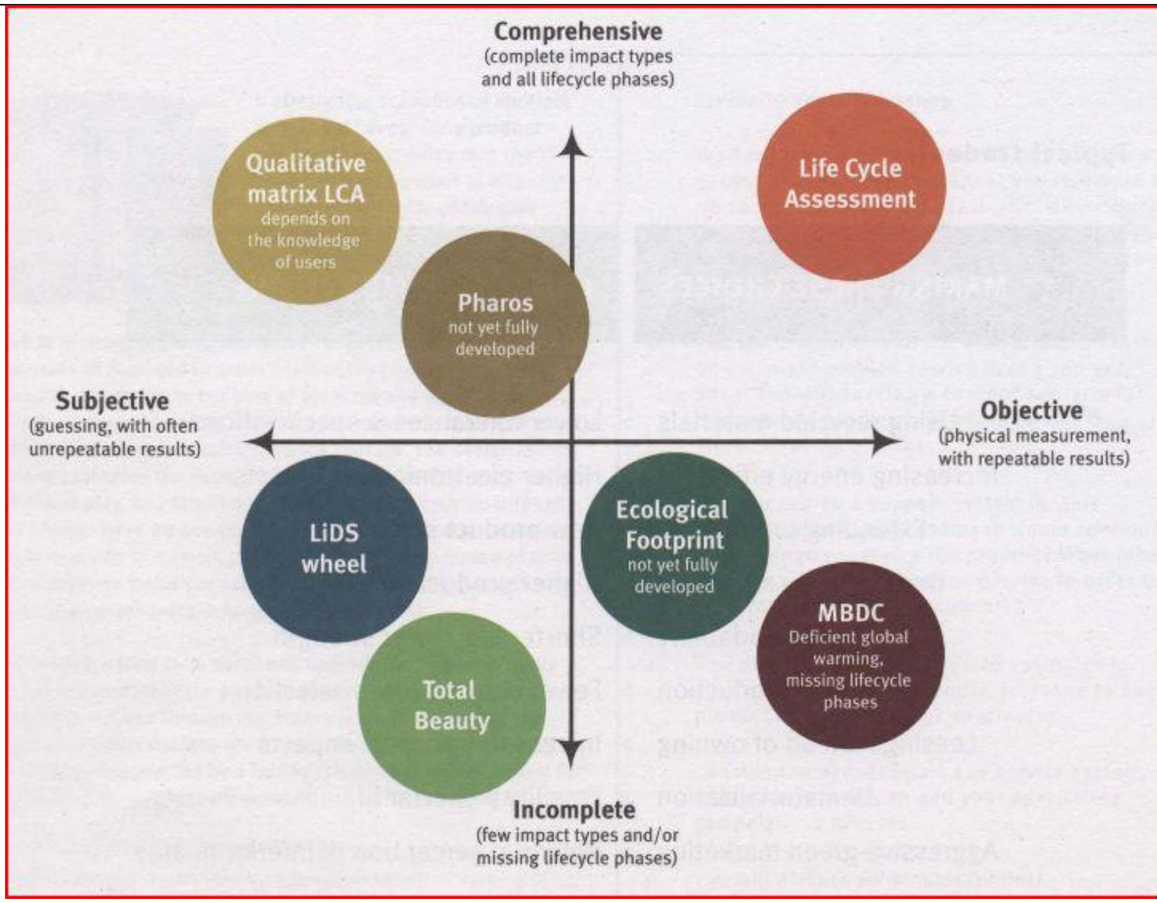

Figure 10: Environmental Impact Assessment Methods, Belletire, St. Pierre, & White, 2007

Life cycle assessment has been noted as one of the most comprehensive methods for environmental impact assessments. Life cycle assessments can been used to compare products, manufacturing processes, and materials in order to identify the most environmentally benign option. LCAs account for environmental impacts of a product, process, or material over their entire lifetime, from extraction to eventual disposal (cradle-to-grave). “LCA takes account of emissions at extraction from nature, materials processing, product manufacturing, distribution and sales, use and upgrading, and end of life disposition to landfill, incineration or recycling, and also includes transportation among these phases” (Belletire, St. Pierre, & White, 2007).

Life cycle stages can differ depending upon product or service and method of assessment. In 2004, Huppes et al. highlighted a variety of lifecycles:

- Design, acquisition, consumption, disposition (ComEd 1996)
- Extraction, design and production, packaging and distribution, use and maintenance, reuse and recycling, and incineration and disposal (Danish EPA)
- R&D, investment, operation (US Army, Fisher 1971)
- Resource extraction, manufacturing, distribution/transportation,. use and maintenance, disposal, recovery, ancillary materials, capital (ISO 14040/14041)
- Introduction, growth, maturity, (Saturation), declining (e.g. business economists)
- Pre-phase, market phase, post-phase (Fassbender-Wynands 2001)
- Research, development, introduction, maturity, decline, abandonment (US Fish and wildlife)

The Eco-Index developed specifies six main lifecycle stages which include materials, packaging, product manufacturing and assembly, transport and distribution, use and service, and end-of-life. The materials stage may be further divided into feedstock, raw materials, and processing (Eco Index, 2010).

There is not a single defined methodology for conducting life cycle assessments. Varying methodologies have been established by governments, private organizations, and non-government organizations. In 1993, the Society of Environmental Toxicology and Chemistry (SETAC) developed a commonly used set of guidelines for conducting life cycle analysis. The SETAC ‘Code of Practice’ separates assessments into four phases: scoping, inventory, impact assessment, and improvement assessment (Ayres, 1995). In 1997, the International Organization for Standardization (ISO) released the ISO 14040 standard, “Environmental management—Life cycle assessment—Principles and framework” (International Organization for Standardization, n.d.). ISO 14040 was updated in 2006, and provides “definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements” (International Organization for Standardization, n.d.). The standard covers previous studies, but does not provide detailed techniques or specific methodologies. In 2006, Scientific Applications International Corporation (SAIC) developed a report for the Environmental Protection Agency (EPA) “Life Cycle Assessment: Principles and Practice”. Similar to the SETAC, the EPA’s report divides the LCA methodology into four components: goal and scope definition, inventory analysis, impact assessment, and improvement assessment (Scientific Applications International Corporation, 2006).

The goal and scope definition stage is intended to define the purpose and methodology of conducting the life cycle analysis, and identify critical information which will affect the meaningfulness of the research. “In this phase, the following items must be determined: the type of information that is needed to add value to the decision-making process, how accurate the results must be to add value, and how the results should be interpreted and displayed in order to be meaningful and usable” (Scientific Applications International Corporation, 2006). The EPA provides six decisions which should be made in the goal and scoping phase: the goal for the project, what type of information is needed, specificity, organization of data and results, scope of study, and ground rules. The inventory stage is the phase in which data needed to perform the life cycle analysis is collected.

Generally this data includes quantitative figures on inputs and waste creation in both the production and disposal of a product or service (Ayers, 1995; Scientific Applications International Corporation, 2006; Portney, 1993). Inventory assessments can assist in the comparison of products or manufacturing processes based off of the quantitative data collected concerning raw material use, energy use, waste created, and other environmental impacts. The impact assessment phase is the stage in which the data collected in the inventory stage is correlated to specific environmental impacts, such as human health and environmental health. The impact assessment is not a risk assessment, and does not look to provide a model to calculate environmental impacts. "Life cycle impact assessment does not necessarily attempt to quantify any specific actual impacts associated with a product, process, or activity" (Scientific Applications International Corporation, 2006). The impact assessment phase can also provide useful comparisons between products, processes, and activities. The final stage of the life cycle analysis the improvement phase which looks to prioritize impacts (Ayres, 1995), in order to improve the impacts identified in the inventory and impact assessments (Portney, 1993).

There are many detailed practices and methodologies for each phase, outlined by the SETAC, EPA, ISO, and other organizations. LCAs are useful in comparing environmental impacts of two products, manufacturing processes, or materials, and have potential to be extended to a product labeling system to assist consumers in purchasing decisions (Portney, 1993). Although life cycle analysis provides a comprehensive approach to identifying environmental impacts of products, processes, and activities throughout their entire lifecycles, there are numerous limitations associated with LCAs and their application.

Researchers have criticized life cycle analysis for lacking comparable units of measurement. Measurements may be given in mass units or in energy units, which may not result in data which cannot be compared to other LCAs which use different units of measurement. Fuels, feedstock's, and wastes measured in different unit's limits the ability of comparing overall inputs with outputs (Ayres, 1995). Lack of uniformity in setting the scope and boundaries for life cycle analysis has also been noted as a limitation its application. Setting the scope for life cycle analysis may be difficult, and the boundaries may be subjective (Arnold, 1995 as cited by Ehrenfeld, 1998). Bias of the researcher may influence the scope of the study, and may result in overemphasis on one environmental impact, such as energy use or waste creation (Ayres, 1995). Energy and raw materials used as well as the pollution and waste created in the lifecycle of a product would be a part of a generally accepted scope of an environmental impact assessment. However, some researchers may argue that further considerations must also be considered, such as energy and raw material which were needed to produce manufacturing equipment (Portney, 1993). Aside from difficulties in setting the boundaries and scope of the LCA, many LCAs assume that the products being compared provide identical utility and service. In a 1993 critique of LCA methodology by Portney, cites the example of a common LCA comparing the environmental impacts of paper cups versus polystyrene cups. "Hot coffee in paper cups burns my fingers by the time I get back to my office from the coffee machine, while coffee in polystyrene cups does not. As a consequence, I sometimes use two paper cups, on inside the other and discard both" (Portney, 1993). Aside from considering a products utility, life cycle analysis do not consider social or economic inputs either.

Life cycle analysis can be not only time consuming, but also expensive. A single LCA can cost upwards of one hundred thousand dollars (Portney, 1993), which can be an unrealistic and unaffordable cost when numerous LCAs must be performed on a variety of products. "LCAs are costly and time-consuming because they are inherently complex and data intensive, subject to technological change, and depend on data which often are proprietary and inaccessible to non-industry researchers" (White & Shapiro, 1993). Conducting LCAs on all consumer products is unrealistic, but conducting LCAs on materials from which products are made of may be a viable alternative.

CHAPTER III

Methodology

After a review of the literature currently available on sustainable development in the textile and apparel industry, a compilation of sustainable indicators associated with sustainable development were gathered. The Eco Index defines an indicator as "performance parameters or attributes that demonstrate environmental impact or improvement" (Eco-Index, n.d.). Although the Eco-Index focuses on Environmental impacts or improvements, other indicators of interest addressed issues such as economic or social impacts and improvements. From these sustainable indicators, a survey was developed which aims to better understand the priority of these indicators. The research methodology employed was composed of a combination of qualitative methods, through use of secondary data, particularly publications and standards developed by various organizations and associations concentrated on sustainability within the textile and apparel industry. A survey methodology was also employed to gather information concerning the overall importance and ease of implementation for various sustainable indicators.

The overall purpose of this study is to better understand current sustainable practices in industry, and prioritize sustainable indicators based on expert insights. The research was designed as an exploratory study of sustainable indicators and their priority and applicability in the sustainable development of the textile and apparel industry. Sustainable development was defined by the 1987 Brundtland Report as 'progress which meets the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs' (World Commission on Environment and Development, 1987). Because sustainable development is not currently a cohesive practice in the industry, creating a basis of sustainability for textile and apparel companies and products will enable effective progress towards sustainability. Creating this basis will ensure development of the industry as a whole and allow companies to promote their efforts towards sustainable development on relevant and generally accepted dimensions of sustainability. An understanding of the foundation upon which sustainability exists for the textile and apparel industry will also allow new entrants and other firms who are integrating sustainability into their business practices and products to make informed decisions which will allow for the most significant impacts. This foundation can act as a building block for sustainable development and measure effective progress for companies and products.

In 2005, Krajnc & Glavic asserted that although many frameworks have been developed to assess the performance of companies using sustainable related indicators, often these indicators are based on different performance measurements in different units, and can be difficult to compare (Krajnc & Glavic, 2005). In the proposed index from Krajnc & Glavic, indicators and performance were grouped into only three dimensions, economic, environmental, and societal. Although those dimensions may adequately cover corporate commitment to sustainability, they do not address all the dimensions of the sustainability of a product. The Eco Index gives more product related dimensions in their proposed index, which closely follow a products life cycle, and include dimensions such as materials, packaging, product manufacturing and assembly, transportation and distribution, use and service, and end-of-life (Eco-Index, n.d.). Other organizations have also developed their own indicators. The Institution of Chemical Engineers (IChemE) has developed indicators for process industries which are grouped under three traditional dimensions: environmental, economic, and social (Azapagic, 2002). Environmental indicators include resource usage, emission, effluents and waste, and another broad category of ‘other’. The economic indicators consist of profit, value, and tax, investments, and other. The social indicators are composed of social indicators, including workplace, society, and other (Azapagic, 2002). There are many different measurements under each broad dimension, which may not be applicable to every processing facility, and it is left to the respondent to choose appropriate metrics. However, there are key indicators in each of the three dimensions, which form a foundation for the sustainability assessment and reporting (Azapagic, 2002). McDonough Braungart Design Chemisty (MBDC) has also developed a certification to act as an eco-label to assess a product's safety to both humans and the environment, as well as design for additional life cycles (MBDC Cradle to Cradle, n.d.). Products are assessed on five dimensions: material health, material reutilization, renewable energy use, water stewardship, and social responsibility (MBDC Cradle to Cradle, n.d.). These dimensions measure both product safety, as well as manufacturing health and safety.

The International Working Group on Global Organic Textile Standard (Global Organic Textile Standard, 2006) has developed a standard which assess the environmental and social dimensions of a product, and covers production, processing, manufacturing, packaging, labeling, exportation, importation, and distribution. GOTS provides guidelines for organic fiber production requirements, material composition requirements, chemical requirements, processing and related chemical requirements. GOTS provides minimum social requirements and criteria, as well as outlining a quality assurance system (Global Organic Textile Standard, 2006).

Many other organizations, working groups, governments, and NGO's have developed index's containing indicators. This research collected and organized 70 indicators from eight organizations into eight dimensions covering both product related aspects as well as traditional sustainability dimensions, such as economic, environmental, and social concerns. This research is highly qualitative in its methodology, and subject to the opinions and bias of the researchers, as well as the target population. These limitations may allow for a more accurate and informed opinion on sustainable development for the textile and apparel industry, but may also have limitations and be subjective.

End-of-life

End-of-life refers to the disposition options available for a product once it is not longer useful to the consumer. Some of these options may include recycling, reuse, repurposing, incineration, and landfill disposal. Indicators associated with products end-of-life include:

- Company has developed an end-of-life management system
- Product is easily disassembled
- Product is designed to be recycled
- Product is designed to be reused, refilled, or re-purposed
- Product is designed to minimize variety of materials
- Material components are identifiable
- Company supports a third party organization for product take-back services
- Company offers a take-back service
- Product is designed to avoid blending materials

Processing and manufacturing

Product processing and manufacturing refer to the value added transition a product goes through to become a finished product. Issues associated with product processing and manufacturing generally include raw material use in processing and harvesting of raw materials, energy and non-renewable resources used during manufacturing, as well as waste and pollution created during processing and manufacturing. Indicators associated with product processing and manufacturing include:

- Company measures solid waste at facility
- Company measures water use at facility
- Company measures energy use at facility
- Company has a plan to minimize number of production methods and operations

- Company has a plan to reduce energy use at facility
- Company has a plan to reduce water use at facility
- Company has a plan to reduce solid waste at facility
- Company has developed an environmental management system at facility
- Company measures quantity and quality of wastewater discharged at facility
- Company measures hazardous waste generated at facility
- Company measures quality of air emissions at facility

Packaging and distribution

Product packaging and distribution include the materials and processes performed to create packaging for a product, as well as the transportation methods to deliver the product to the point of purchase or directly to the consumer. Issues associated with product packaging and distribution often includes packaging materials, waste created from packaging, and energy used in transportation. Indicators associated with packaging and distribution includes:

- Packaging material is minimized
- Packaging is designed to be recycled
- Packaging and product weight are minimized
- Company has a packaging restricted substance list
- Post-consumer recycled content is used in packaging
- Company uses efficient transport system
- Packaging is sourced from certified and traceable sources
- Packaging is designed to be reused

Materials

Materials are all components, both natural and man-made, from which a product is created. Materials can have a large impact on the use as well as the disposal options for a product. Indicators associated with materials include:

- Avoiding toxic materials
- Utilizing pre-consumer recycled materials
- Utilizing post-consumer recycled materials
- Using natural fibers
- Creating or adopting a restricted substance list
- Making restricted substance list available to public
- Efficient use of raw material
- Identifying and eliminated chemicals of concern
- Sourcing materials from renewable sources
- Using materials which require less water to cultivate
- Sourcing materials locally
- Using materials which will degrade back into the environment less than 5 years after use
- Using certified organic fibers
- Using materials which create less environmental impacts
- Using materials which can be recycled back into production as inputs
- Using materials which require less energy to cultivate
- Using materials which create less waste

Aftercare and Use

Aftercare and use of a product are activities which the product is subjected to after the point of purchase. Often this includes laundering and care activities, as well as any upgrades, repairs, refurbishments the product may require. Aftercare and use indicators may include:

- Company offers repair/refurbishment services
- Product has a warranty
- Company offers product upgrades
- Product is designed for low impact care and laundering
- Product is designed for durability and longevity
- End-of-life options are communicated to consumers
- High quality materials are used

Social Issues

Social issues are those which impact significant stakeholders. Many social issues are focused on employee health and safety, but may also be corporate responsibility issues, such as building community infrastructure. Social indicators may include:

- Employees are paid living wages
- Third party certification for social responsibility
- Company has developed and corporate ethics/fair labor statement and made it publically available
- Workers are trained
- No use of child labor
- Employees have freedom of association and collective bargaining rights
- Employment is freely chosen

- Company has developed an infrastructure and provides services for the public benefit
- Some senior management is hired from local community

Process

To begin with sustainable indicators were gathered from seven associations, auditors or certifiers, as well as industry groups. These groups were chosen because of their reputable standing in industry, as well as their inclusion of product related indicators. The seven organizations chosen included Michael Braungart Design Chemistry Cradle-to-Cradle certification, Bluesign for textile manufacturers, the Eco-Index developed in part by the Outdoor Industry Association, the Global Organic Textile Standard, Worldwide Responsible Accredited Production (WRAP), Global Reporting Initiative, as well as the Better Cotton Initiative.

From these seven organizations, 70 total indicators were gathered. These indicators are not a value-based measurement, but rather represented general ideas or practices related to product life cycle as well as corporate policies and practices. To avoid redundancy, indicators which were extremely similar and overlapping were narrowed to one representative indicator. Indicators which were specific to only one organization or product were eliminated. These initial 70 indicators were grouped into eight broad concepts, or dimensions, both product lifecycle related, as well as corporate practice and policy related. The eight dimensions chosen included economic indicators, environmental indicators, social indicators, material indicators, and consumer based indicators, end-of-life indicators, lifecycle indicators, as well as an ‘other’ dimension, to catch any indicators which were not easily grouped within another dimension. Indicators generally cover a variety of facets of sustainability, but usually they are divided into environmental indicators, economic indicators, and social indicators. There may be core indicators (most significant, required indicators) and supplemental indicators (Krajnc & Glavic, 2005). Traditionally, indicators are most useful when they are quantifiable with a unit of measurement, and tracked periodically (Krajnc & Glavic, 2005). A possible limitation of this methodology is the subjectivity of the chosen indicators.

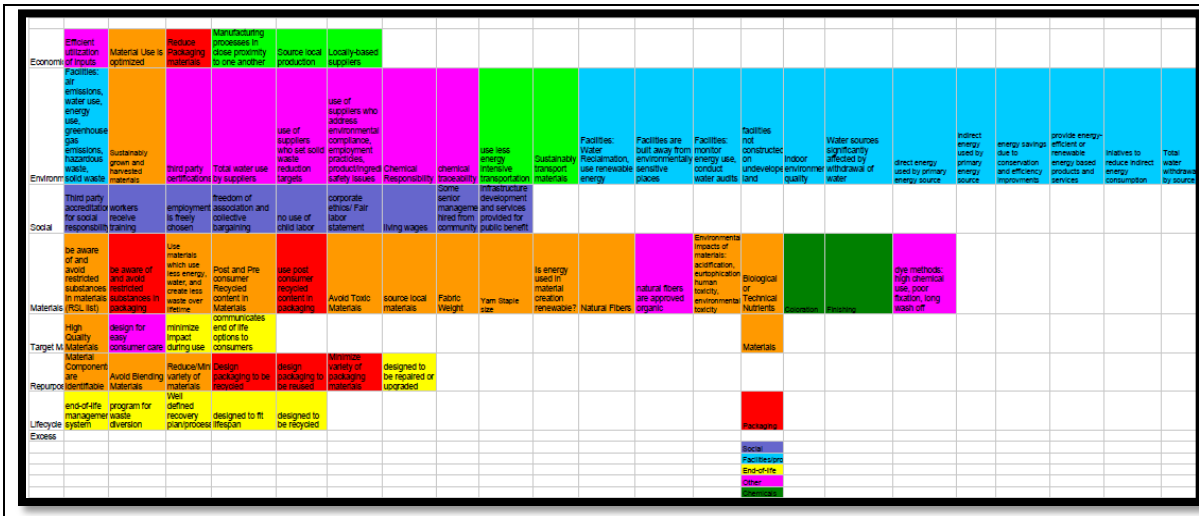

Figure 11: Sustainable Indicators Chart

Sample Population

The sample population chosen was conducted in a method similar to that of a Delphi study. The sample population was a target population of experts, practitioners, and experienced individuals in the general field of sustainability in the textile and apparel industry. This target population was a combination of a non-probability judgment sample as well as a partial snowball sample. Participants were selected in hopes of obtaining the most insight into the topic of interest. The initial participants were chosen based on contacts made by the primary researcher, or secondary researchers, at conferences, workshops, meetings, or previous associations. These contributors were contacted requesting their participation, and a selected few were requested to forward the survey to associates who also had experience in the field of textile and apparel sustainability. Soliciting the help of initial selected participants in identifying other experts in the research area allows for a larger population and provides more applicable results. The possible disadvantage of this method of sampling is that it may not be generalized or representative of the larger population, and this could affect the accuracy of the results. All participants and their associated companies were kept anonymous, which follows traditional Delphi methodology.

Survey Methodology

A procedure was developed in order to identify and contact potential participants. This procedure was documented and submitted to the IRB of North Carolina State University for approval. The nature of the study allowed for IRB exemption approval.

Participants were divided into two groups based on those who were contacted to complete the survey directly, and those who would be requested to complete the survey and also to solicit the participation of other known experts. Each group was contacted by email to ask for their participation in the research study. Two initial participation request letters were drafted and sent to the appropriate group. A link to the web-based survey was included in both of the initial emails. (Appendix A1). Participants remained anonymous, and at no point requested to identify themselves or their associated companies. Because participants remained anonymous, another letter was sent by email a few weeks later to remind all participants to complete the study (Appendix A2).

The survey was developed based on the initial 70 indicators selected. The survey, containing 56 questions and covered seven dimensions: end-of-life, packaging and transportation, production & manufacturing, materials, consumer use and aftercare, end-of-life, and social issues. Each section began with a screening question to identify qualified participants. Survey respondents were asked to indicate how long they had been working in each area to gauge general understanding and expertise.

Respondents who indicated having worked less than one year in a various area were skipped ahead to the next section, to avoid responses which were not based upon informed experience or expertise. If respondents indicated they had more than one years of experience working in an area, they were asked to complete the section. Respondents were first asked to list 2-3 self-identified indicators related to the economic, environmental, and social implications of each dimension, and then asked to rate provided indicators. Survey respondents were prompted to rate various provided sustainable indicators on a semantic differential scale of overall importance, from ‘not important’ to ‘very important’. Survey respondents were then asked to repeat the differential scale in terms of ease of implementation, from ‘easy to implement’ to ‘difficult to implement’. These questions were designed to help prioritize sustainable indicators. Each section of the survey continued on in this fashion, asking respondents to list self-identified economic, environmental, and social indicators relating to different dimensions of a products life cycle.

The survey was hosted by an online survey instrument, Survey Monkey. Results were recorded into the online instrument, which is password protected and SSL encrypted.

CHAPTER IV

RESULTS

This chapter details the results from the Sustainability Insights study. The results are presented in sections similar to the survey: end-of-life, processing and manufacturing, packaging and distribution, materials, use and aftercare, and social responsibility.

Company/Activities Overview

To better understand current activities in which respondents partake, all respondents were initially asked to complete a set of questions. It was of interest to see how many companies currently have a Corporate Social Responsibility statement and/or an Environmental Health and Safety policy. Of the 18 respondents, 14 reported having a Corporate Social Responsibility statement, while 15 reported having an Environmental Health and Safety policy. It was also of interest whether these statements and policies were available for public review. Of the 14 respondents, who indicated they did have a Corporate Social Responsibility statement, 11 indicated that it was available for public review. Of the 15 respondents who indicated they had an Environmental Health and Safety Policy, 10 indicated it was available for public review.

Respondents were asked what their firms currently produce, design, or retail in terms of product marketed as sustainable, green, eco-friendly, or environmentally friendly. Of the 18 respondents, 16 reported that they currently produced, designed, or retailed a product marketed as sustainable, green, eco-friendly, or environmentally friendly. Respondents were asked to indicate from a list all characteristics which made their product sustainable, green, eco-friendly, or environmentally friendly. 11 reported producing a product made from recycled material, while 9 reported producing a product which was recyclable. Six reported producing an organic product, while five reported producing a product which was energy efficient and water efficient. Four reported producing a product which was reusable, and three reported producing a product considered fair trade and also low/Nonpolluting. Other characteristics reported included use of natural fibers.

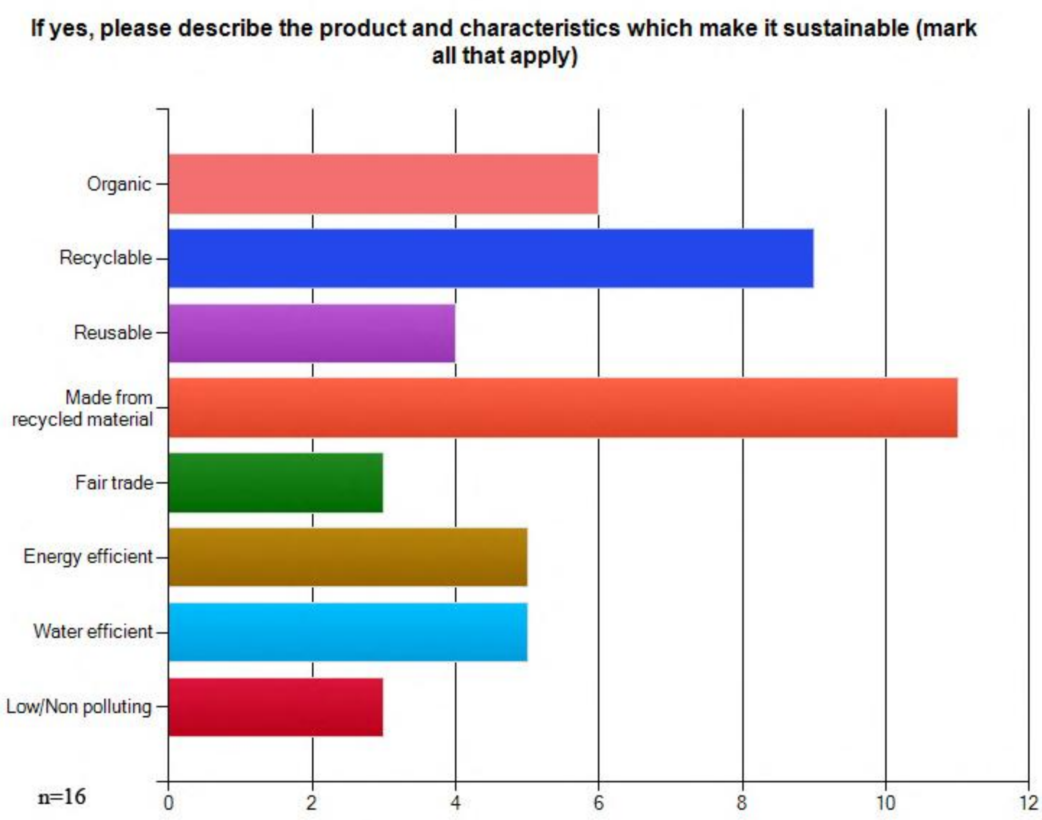

Figure 12:Characteristics of sustainable, green, eco-friendly, environmentally friendly products

End-of-life

Each section of the survey began by establishing expertise. In hopes of obtaining insights and expertise in an area, any respondent who indicated less than one year of experience in an area were excluded from responding to that section. Of the 17 initial respondents, 5 indicated having less than one years of experience working with product end-of-life, while 3 indicated having one to three years of experience, 2 indicated having three to five years of experience, and 7 indicated having five or more years of experience with product end of life (See Figure 13).

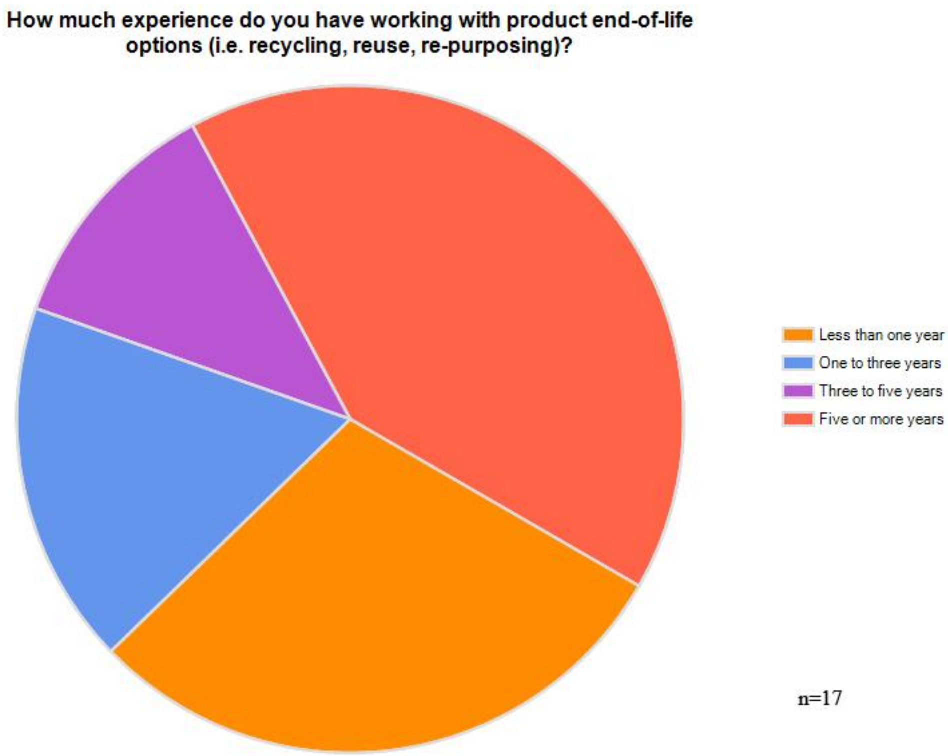

Figure 13: End-of-life experience

Respondents were then given an opportunity to list self-identified economic, social, and environmental issues relating to product end-of-life.

Social

- human chemical exposure during recycling or reuse fairness of distribution
- Consumers need to know it's not just one or a few used clothing items it's billions Donate- Recycle - Do not Throw Away
- lack of incentives to find new puposes for recyled materials
- toxins in our water ways, affecting human and wildlife health solid waste toxins
- low impact on community and environment
- C8, C6 chemistries in flurochemical water repellent finishes and their retention in mother's milk. Perhaps the issue that it is hard to clarify with certainty what a recycled blended and carded fibrous web has in it. Perhaps this is too specific, but sometimes it is difficult to know with certainty what all of the components of a recycled material are.
- Labor needed to sort and cut garments is low-wage medium-skill work which should be monitored just like garment factory workers, but it is difficult to get that level of trasnparency. Another issue may be second hand goods going to under-developed countries, which can offer better standard of living but also poses the problem of what to do with that clothing when it reaches it's true end-of-life in a country with no textile recycling inrastructure.
- Displacement of jobs due to reuse. Uncontrolled working conditions for manual part of the recycling process.

Economic

- fair/accurate marketing of recycled/reused material quality of product
- there is a market 'crade to cradle' is a answer but not they only answer for real world problem that needs real world solution
- lack of sufficient infrastruture to make recycling of mixed fiber textile waste cost-beneficial
- expense of using virgin rather than recycled materials expense of finding and securing more landfill space
- supports education,jobs,economic development,supports entrepreneurship more emphasis needs to be understood about the end of life product and its effect
- Fuel transport costs associated with recycling materials that have to be taken to specific centers. The increased cost of moving from C8 to C6 chemistries for durable water repellent finishes.
- Waste is low value because it is not a homogenous pure raw material. It needs to be processed which costs money. Also trasnsportation to get garments to a centralized recycling center costs money because it is a reverse distribution model which is logistacally backwards.
- Cost. Increased energy use/cost to transport for recycling.

Environmental

- not enough landfill space environmental chemical exposure
- 5% of landfill is comprised of PCTW
- there is no "away" when we throw something "away" decrease in biodiversity due to polluted environemnts
- That is the water process is cleaned,and reused as well as the residual fiber or waste can be finally disposed of without a high degree of impact on the environment
- The environmental issues associated with formaldehyde in flame retardent finishes. The fact that we have so many blended fabric (multiple fiber types in one textile) means that recycling is difficult as compared to single component textiles.
- Landfill space is limited and must be managed for eternity to avoid the breakdown of waste into tosic by-products. Incineration is also concerning because even with the best scrubbing technology we can emit dioxins and are left with toxic flyash as the byproduct.
- Increased energy use/cost to transport for recycling. Too strong a focus on recycling or biodegradability instead of on total life cycle impact.

Figure 14: Self-identified issues of concern relating to product end-of-life

Respondents were then provided with a semantic differential scale and several end-of-life indicators and asked to rate each indicator on a scale of 1-7 in terms of overall importance. Respondents identified a **product being designed to be reused, refilled, or repurposed** as the most important indicator with an average rating of 5.45 out of 7. Being able to **identify material components** was listed as the second most important indicator, with an average rating of 5.36 out of 7. Respondents reported **designing a product to be recycled** as the third most important indicator, with an average rating of 5.27 out of 7. Respondents indicated **company offering a take back service** as the least important end-of-life indicator, with an average rating of 4.18 out of 7. Other indicators were ranked from least important to most important as follows:

- **Product is designed to avoid blending materials** (average rating of 4.36 out of 7)
- **Product is easily disassembled** (average rating of 4.64 out of 7)
- **Product is designed to minimize variety of materials** (average rating of 4.82 out of 7)
- **Company supports a third party organization for take back services** (average rating of 4.91 out of 7)
- **Company has an end-of-life management system** (Average rating of 5.00 out of 7)

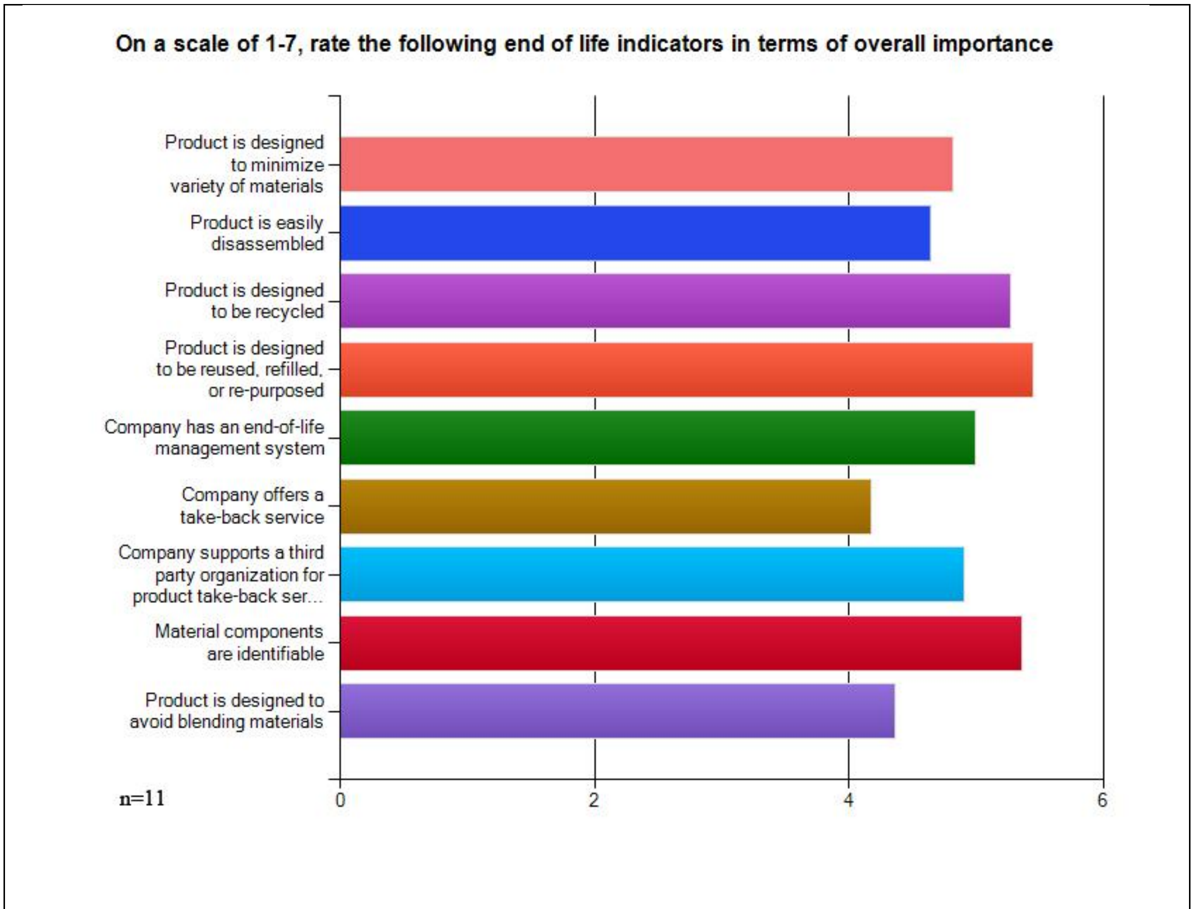

Figure 15: End-of-life indicators overall importance

To help further understand the priority and importance of sustainable indicators, respondents were then asked to choose the top three most important indicators of the end of life indicators provided.

Figure 16: Forced ranked end-of-life indicators

Respondents were also asked to rate each indicator on a semantic scale of 1 to 7 in terms of ease of implementation, with seven being difficult to implement. Respondents indicated **identifying material components** as the easiest indicator to implement with an average rating of 2.91 out of 7. **Supporting a third party organization for take back services** was indicated as the second easiest indicator to implement, with an average rating of 3.10 out of 7. The third indicator which respondents rated as easy to implement was **designing a product to be reused, refilled, or re-purposed**, with an average rating of 3.45 out of 7. Respondents indicated a **company operated take-back service** to be the most difficult indicator to implement, with an average rating of 4.80 out of 7. Other indicators were ranked from easy to implement to difficult to implement as follows:

- **Product is designed to be recycled** (average rating of 3.73 out of 7)
- **Product is designed to minimize variety of materials** (average rating of 3.80 out of 7)
- **Company has an end of life management system** (average rating of 3.82 out of 7)
- **Product is easily disassembled** (average rating of 4.09 out of 7)
- **Product is designed to avoid blending materials** (average rating of 4.50 out of 7)

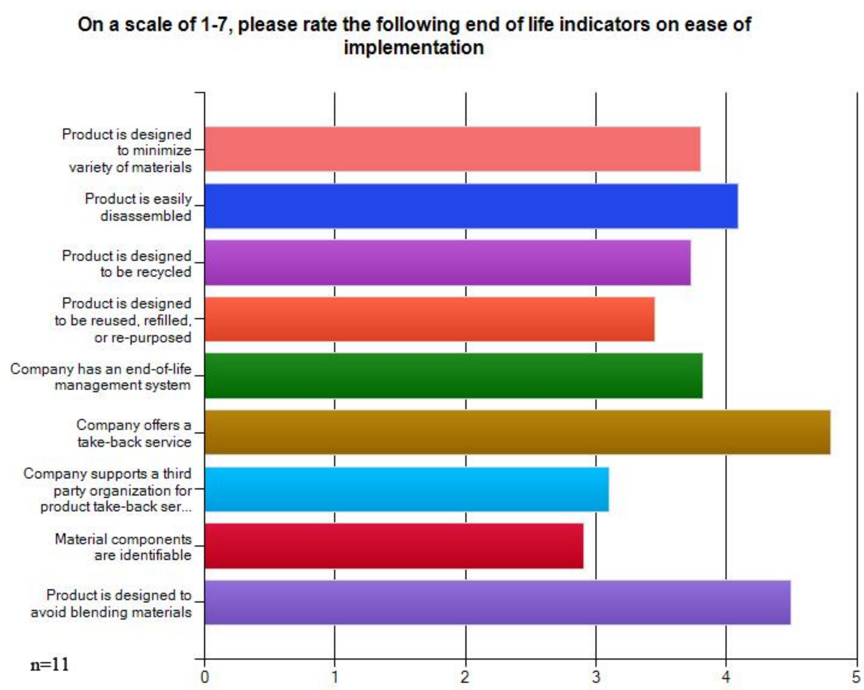

Figure 17: End-of-life indicators ease of implementation

Processing and manufacturing

Of the 16 processing and manufacturing respondents, 2 indicated having less than one years of experience working with processing and manufacturing, while 1 indicated having one to three years of experience, 2 indicated having three to five years of experience, and 11 indicated having five or more years of experience with processing and manufacturing (See Figure 18).

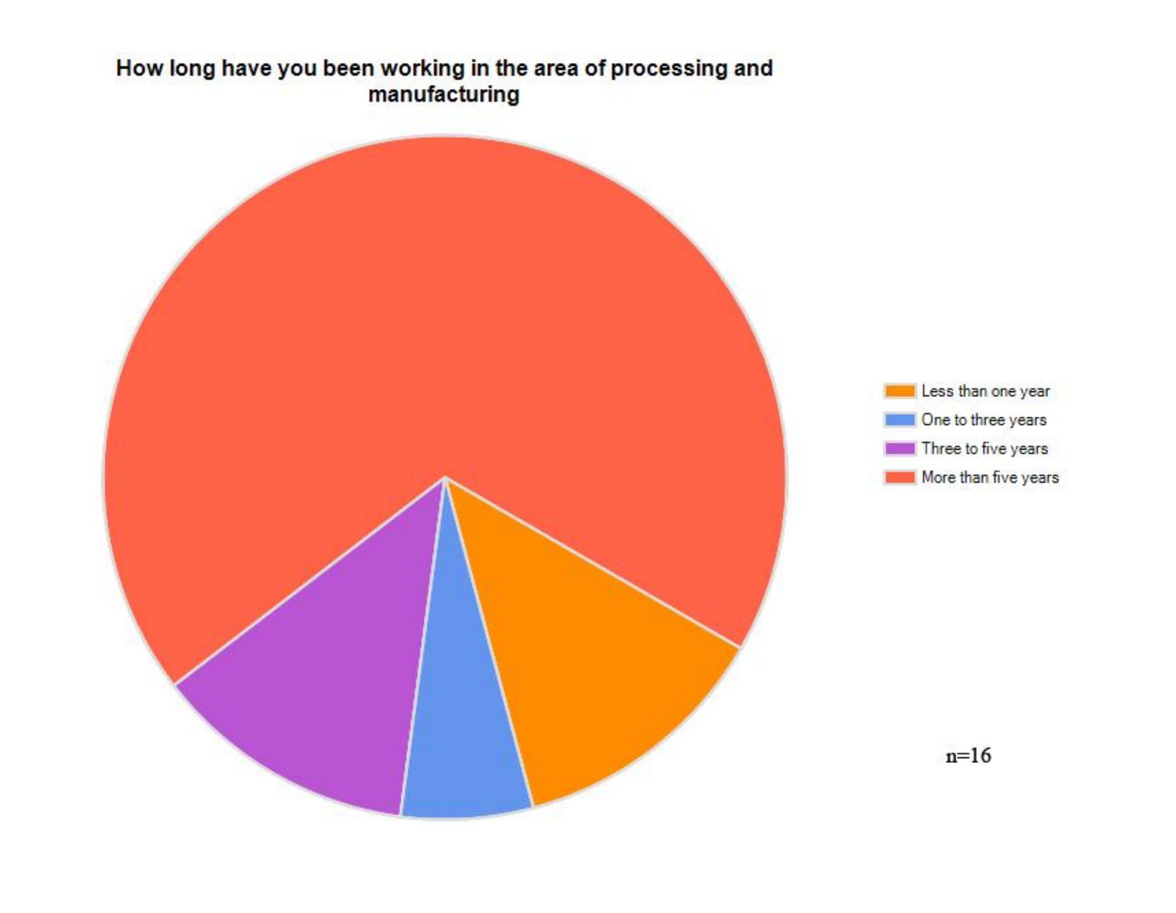

Figure 18: Processing and manufacturing experience

Respondents were then given an opportunity to list self-identified economic, social, and environmental issues relating to processing and manufacturing.

Social

- development worker-friendly environments in third world nations
- worker safety equitable pay and benefits
- lack of enforcement of immigration laws
- control of expense - keeping prices viable control of toxins used in processes
- that manufacturing of the end product as close to the source as possible. Less outsourcing
- Employee Safety and the cost of insurance claims for on-the-job incidents. Union issues.
- low worker wages in factories and farms worker discrimination and exploitation

Economic

- communicating that sourcing from the Western hemisphere is profitable
- Global wages Carbon footprint due to global shipment of goods into America from abroad
- increasing raw materials prices (yarn) Increasing taxes and benefit costs to small business
- control of expense - keeping margins viable cost of inputs
- Product is manufactured and processed to support local economy such as Made In US. At this time less than 13% of products manufactured support local economy
- The increased cost of complying with environmental regulations like the C8, C6 chemistry issue and how manufacturers in the US and Europe are competing over price with manufacturers in companies that do not require compliance with environmental regulations. The increased cost of raw materials (specifically petroleum based).
- Consumers want to pay the lowest price for a product, not the price it costs to make it. Commodity markets and futures markets add volatility to the whole supply chain.

Environmental

- how to meet s-t environmental goals while maintaining profitability
- Reduced chemical effluents Reduced energy consumption
- lack of incentives to recycle, repurpose
- energy use waste from processes
- Waste in local landfills or waste sent to 3rd world countries to dispose of. Harmful chemicals and residual waste dumped in our landfills. Not supporting re-cycle re-use
- Wastewater Treatment Issues (is the released water pH acceptable, are there still harmful chemicals in the water)?. Smoke stack emissions (are they affecting the air quality of the surrounding communities?)
- Waste -- solid waste (fabric cutting scraps) and water pollution from dyeing and finishing. Resource consumption -- high energy and water use to make textiles.

Figure 19: Self-identified issues of concern relating to processing and manufacturing

Respondents identified two indicators as equals for most important in terms of processing and manufacturing. **Company measures energy use at facility** had average rating of 6.10 out of 7. **Company measures hazardous waste generated at facility** was also given an average rating of 6.10

out of 7. Respondents reported that a **company having a plan to reduce energy use at facility** as the third most important indicator, with an average rating of 6.00 out of 7. Respondents indicated **company has a plan to minimize number of production methods and operations** as the least important processing and manufacturing indicator, with an average rating of 4.27 out of 7. Other indicators were ranked from least important to most important as follows:

- **Company measures water use at facility** (average rating of 5.90 out of 7)
- **Company measures quantity and quality of wastewater discharged at facility** (average rating of 5.90 out of 7)
- **Company has a plan to reduce water use at facility** (average rating of 5.64 out of 7)
- **Company has developed an environmental management system at facility** (average rating of 5.45 out of 7)
- **Company measures quality of air emissions at facility** (Average rating 5.30 out of 7)
- **Company has a plan to reduce solid waste at facility (**Average rating of 5.10 out of 7)
- **Company measures solid waste at facility** (Average rating of 4.80 out of 7)

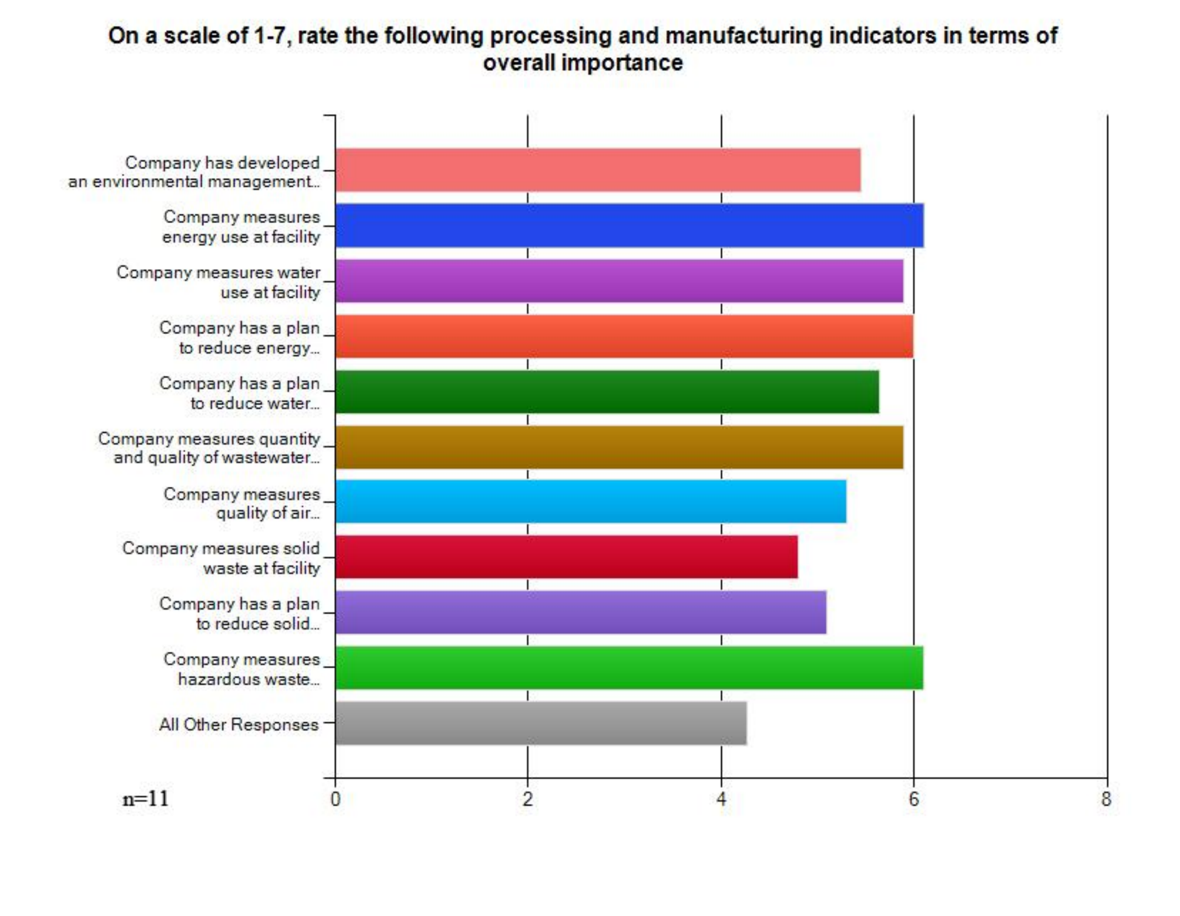

Figure 20: Processing and manufacturing indicators overall importance

To help further understand the priority and importance of sustainable indicators, respondents were then asked to choose the top three most important processing and manufacturing indicators of the indicators provided.

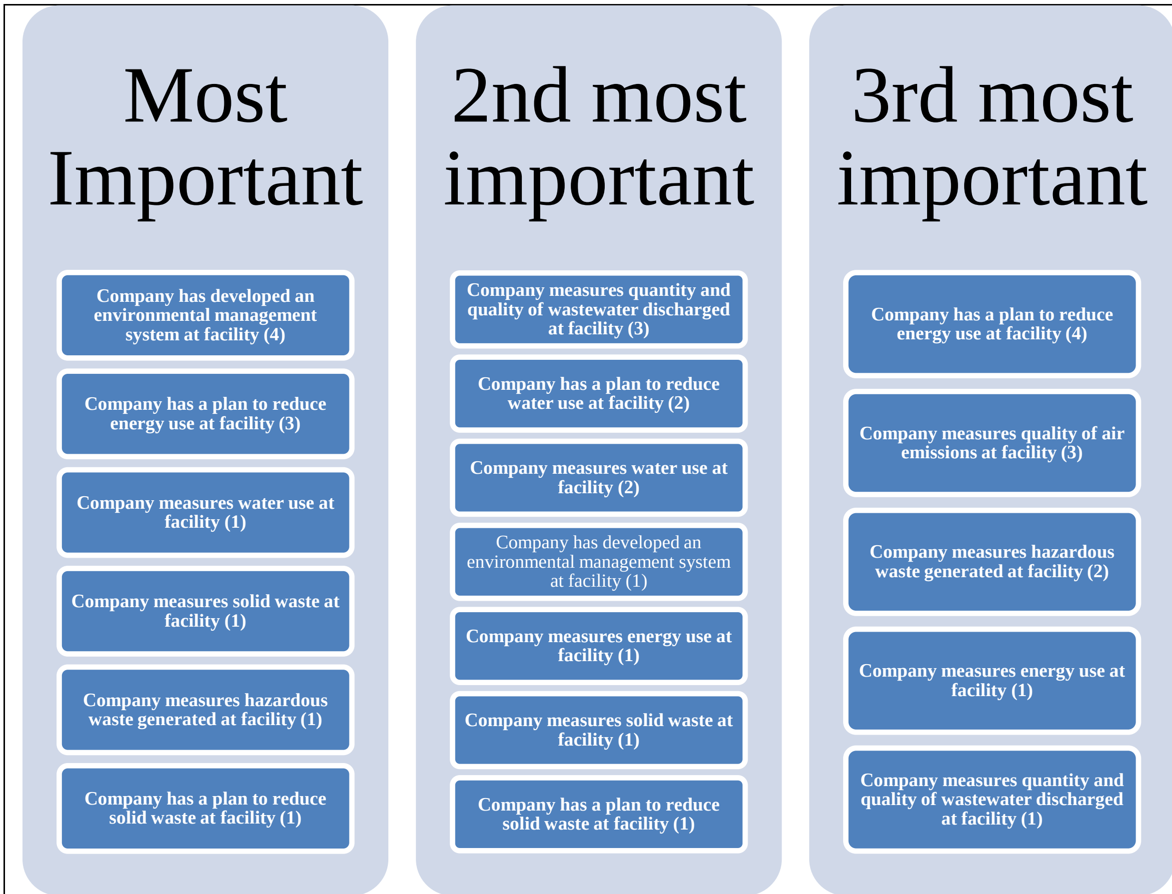

Figure 21: Forced ranked processing and manufacturing indicators

Again respondents were prompted to rate each indicator on a semantic scale of 1 to 7 in terms of ease of implementation, with seven being difficult to implement. Respondents indicated **measuring water use at facility** as the easiest indicator to implement with an average rating of 2.60 out of 7. **Measuring energy use at facility** was indicated as the second easiest indicator to implement, with an average rating of 2.90 out of 7. The third easiest indicator to implement was **measuring solid waste at facility**, with an average rating of 3.00 out of 7. **Developing an environmental management system at the facility** was reported to be the most difficult indicator to implement, with an average rating of 4.70 out of 7. Other indicators were ranked from easy to implement to difficult to implement as follows:

- **Company measures air emissions at facility** (average rating of 3.20 out of 7)
- **Company measures quantity and quality of wastewater discharged at facility** (average rating of 3.30 out of 7)
- **Company has a plan to reduce water use at facility** (average rating of 3.45 out of 7)
- **Company measures hazardous waste generated at facility** (average rating of 3.50 out of 7)
- **Company has a plan to reduce energy use at facility** (average rating of 3.70 out of 7)
- **Company has a plan to reduce solid waste at facility** (average rating of 3.90 out of 7)
- **Company has a plan to minimize number of production methods and operations** (average rating of 4.20 out of 7)

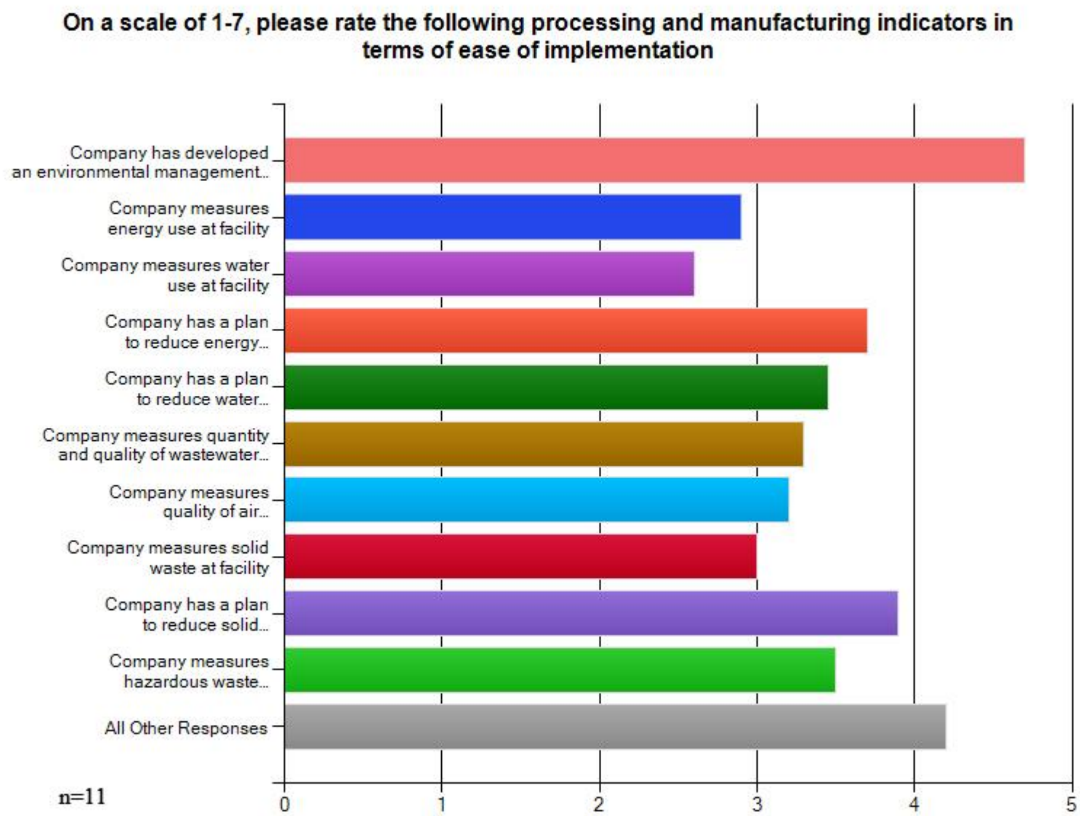

Figure 22: Processing and manufacturing indicators ease of implementation

Packaging and distribution

Of the 13 initial respondents, 5 indicated having less than one years of experience working with packaging and distribution, while 1 indicated having one to three years of experience, 2 indicated having three to five years of experience, and 5 indicated having five or more years of experience with packaging and distribution (See Figure 23).

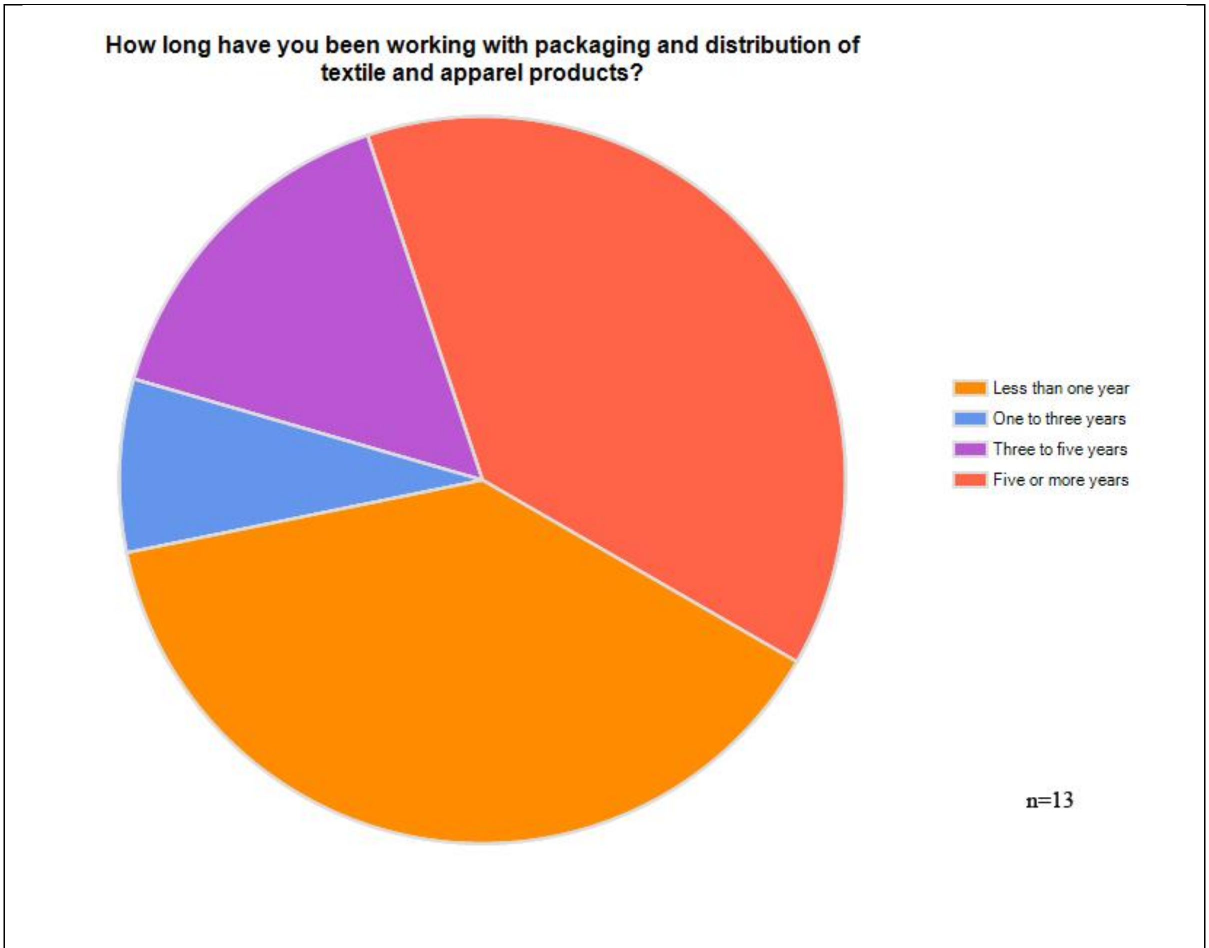

Figure 23: Packaging and distribution experience

Respondents were then given an opportunity to list self-identified economic, social, and environmental issues relating to packaging and distribution.

Social

- safety for workers fatigue of workers
- Product packaging is as re-usable and or recyclable as possible. Is made from re-cycled materials whenever possible

Economic

- efficient and automated processes reusable materials
- Packaging is done as close to the manufacturing as possible, saves energy, fuel, and impact on the environment

Environmental

- reusable materials costs for transportation
- Packaging inks, packaging material, and disposal of the packaging material are as safely manufactured as possible and have labeling that supports re-use re-cycle

Figure 24: Self-identified issues of concern relating to packaging and distribution

Respondents were then provided indicators which related to packaging and distribution, and asked to rate them on a 7 point semantic differential scale in terms of overall importance. **Company use of an efficient transport system** was identified as most important, and received an average rating of 4.83 out of 7. Respondents identified two indicators as equals for second most important in terms of packaging and distribution. **Packaging designed to be reused** had average rating of 4.71 out of 7. **Packaging and product weight are minimized** was also given an average rating of 4.71 out of 7. The least important packaging and distribution indicator was **packaging sourced from certified and traceable sources** with an average rating of 3.17 out of 7. Other indicators were ranked from least important to most important as follows:

- **Company has a Packaging Restricted Substances List (PRSL)** (average rating of 3.67 out of 7)
- **Packaging material is minimized** (average rating of 4.29 out of 7)

- **Packaging is designed to be recycled** (average rating of 4.33 out of 7)
- **Post-Consumer recycle content is used in packaging** (average rating of 4.50 out of 7)

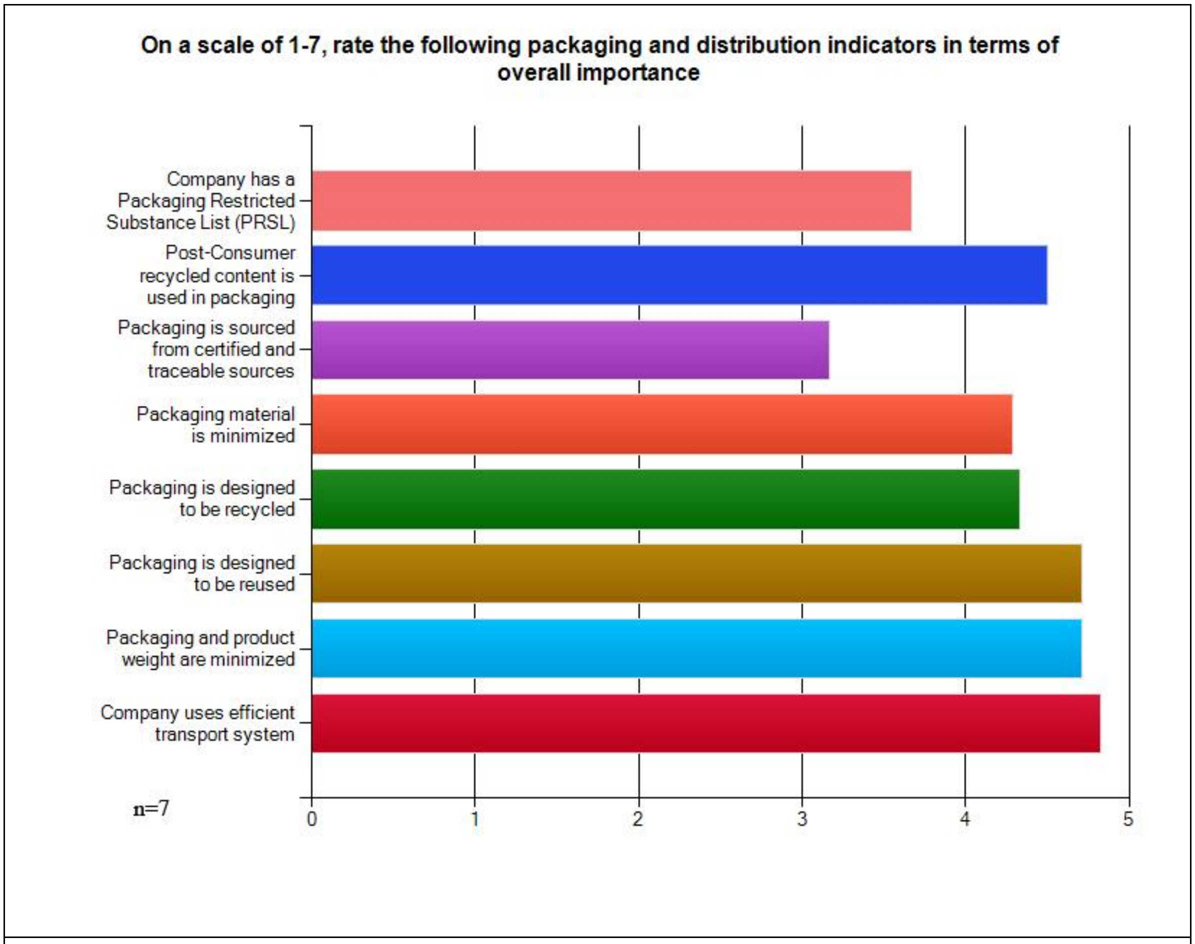

Figure 25: Packaging and distribution indicators overall importance

Respondents were then asked to choose the top three most important indicators of the packaging and distribution indicators provided.

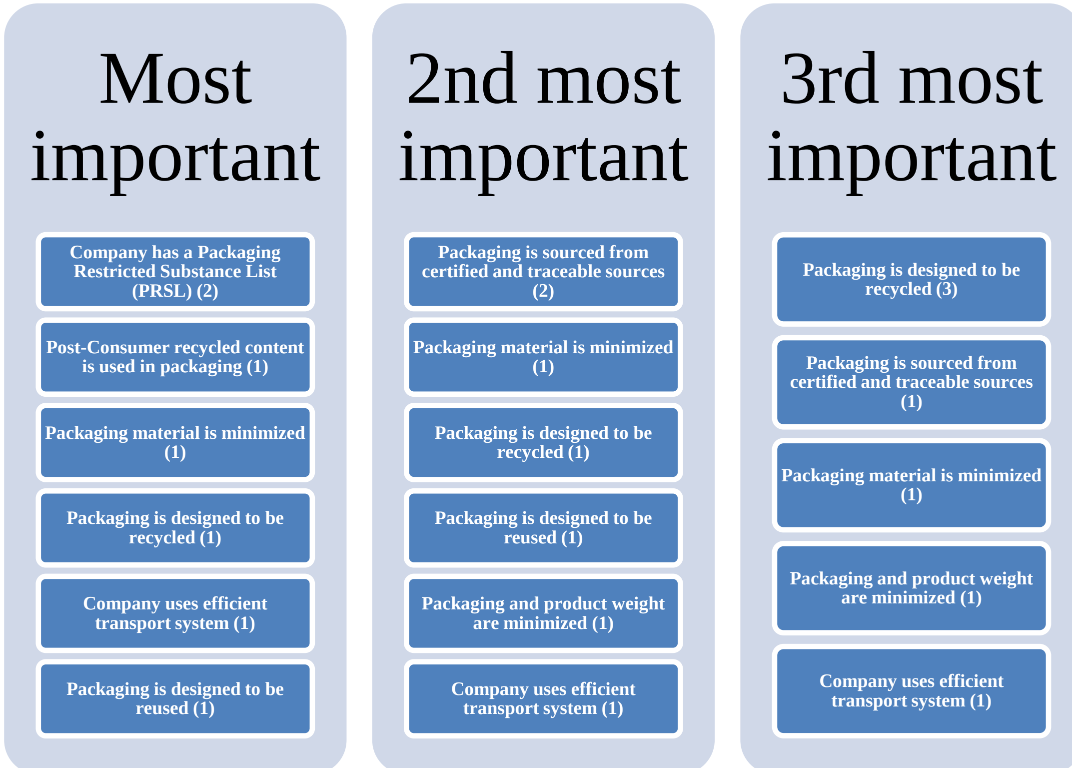

Figure 26: Forced ranked packaging and distribution indicators

To measure ease of implementation, respondents were asked to rank each packaging and distribution indicator on a seven point semantic scale, 1 being easy to implement and 7 being difficult to implement. Respondents indicated **Company uses efficient transport system** as the easiest indicator to implement with an average rating of 2.20 out of 7. **Company adopting or creating a Packaging Restricted Substance List (PRSL)** was indicated as the second easiest indicator to implement, with an average rating of 3.00 out of 7. The third easiest indicator to implement was **minimizing packaging material**, with an average rating of 3.25 out of 7. **Packaging designed to be reused** was reported to be the most difficult indicator to implement, with an average rating of 4.00 out of 7. Other indicators were ranked from easy to implement to difficult to implement as follows:

- **Packaging is sourced from certifiable and traceable sources** (average rating of 3.40 out of 7)
- **Packaging and product weight are minimized** (average rating of 3.40 out of 7)
- **Post-consumer recycled content is used in packaging** (average rating of 3.50 out of 7)
- **Packaging is designed to be recycled** (average rating of 3.50 out of 7)

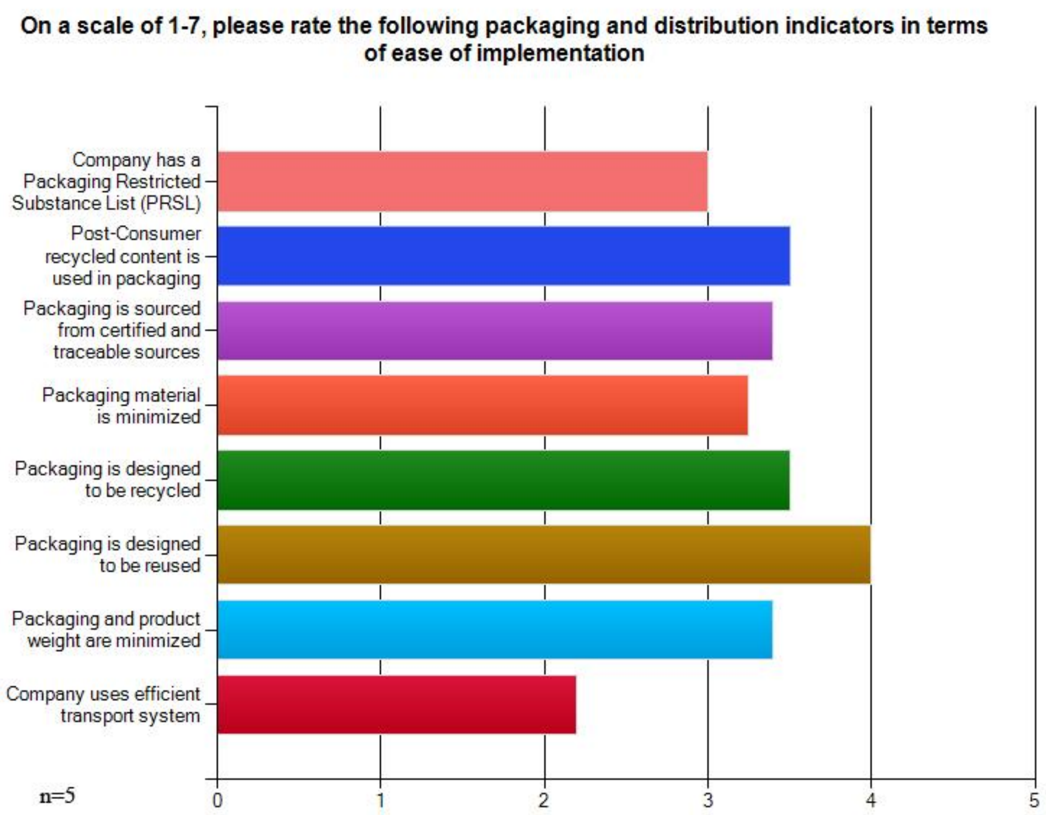

Figure 27: Packaging and distribution indicators ease of implementation

Materials

Of the 10 initial respondents, 4 indicated having less than one years of experience working with materials, while 2 indicated having one to three years of experience, 1 indicated having three to five years of experience, and 3 indicated having five or more years of experience with materials (See Figure 28).

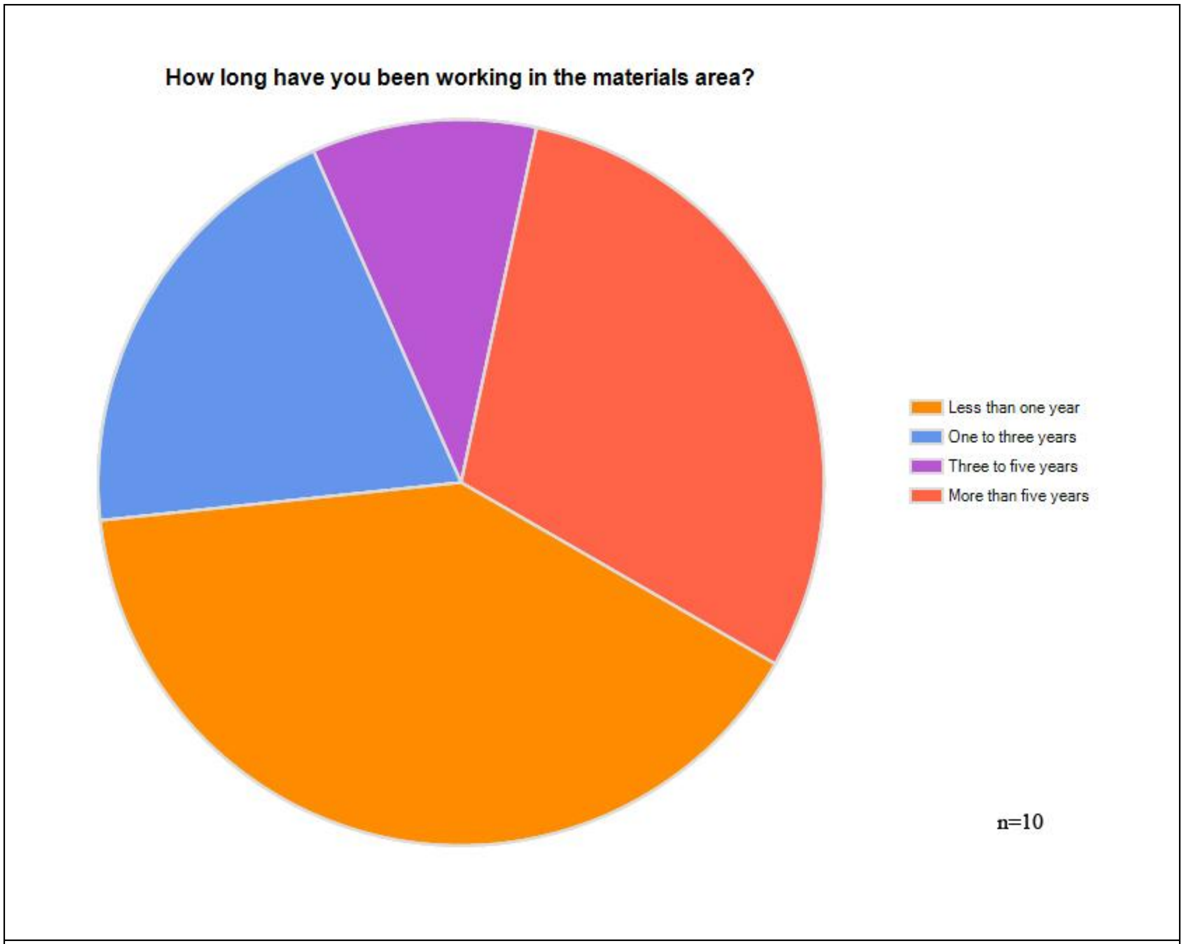

Figure 28: Materials experience

Respondents were then given an opportunity to list self-identified economic, social, and environmental issues relating to processing and manufacturing.

Social	Economic	Environmental
• Non Toxic and recyclable re-usable • exposure to chemicals	• Light in weight and easily disposed of recyclable. and re-usable if possible • Instability of commodity raw material prices. Price pressure for making and selling cheaper products goes down the supply chain to the material supplier	• Non Toxic, safe materials in construction of the packaging, low impact on the environment • Managing Toxic chemicals or by-products. Maximizing yield and minimizing waste.

Figure 29: Self-identified issues of concern relating to materials

Respondents were then provided indicators which related to materials, and asked to rate them on a 7 point semantic differential scale in terms of overall importance. **Utilizing post-consumer recycled materials** was identified as most important, and received an average rating of 7.00 out of 7. Respondents identified **avoiding toxic materials** as the second most important in terms of material indicators with an average rating of 5.67 out of 7. **Using materials which create less environmental impacts** was rated as the third most important indicator with an average rating of 5.50 out of 7. The least important materials indicator was **making restricted substance list available to the public** with an average rating of 1.00 out of 7. Other indicators were ranked from least important to most important as follows:

- **Using materials which can be recycled back into production as inputs** (average rating of 2.00 out of 7)
- **Sourcing materials locally** (average rating of 2.00 out of 7)

- **Creating a restricted substance list** (average rating of 2.00 out of 7)
- **Using materials which create less waste** (average rating of 3.00 out of 7)
- **Using natural fibers** (average rating of 3.00 out of 7)
- **Utilizing pre-consumer recycled materials** (average rating of 3.00 out of 7)
- **Using materials which require less water to cultivate** (average rating of 3.50 out of 7)
- **Identifying and eliminating chemicals of concern** (average rating of 3.50 out of 7)
- **Efficient use of raw materials** (average rating of 4.00 out of 7)
- **Using materials which will degrade back into the environment less than 5 years after use** (average rating of 5.00 out of 7)

Unfortunately, there were three material indicators which were not ranked at all. These indicators included **sourcing materials from renewable sources**, **using certified organic fibers**, and using materials which require less energy to cultivate.

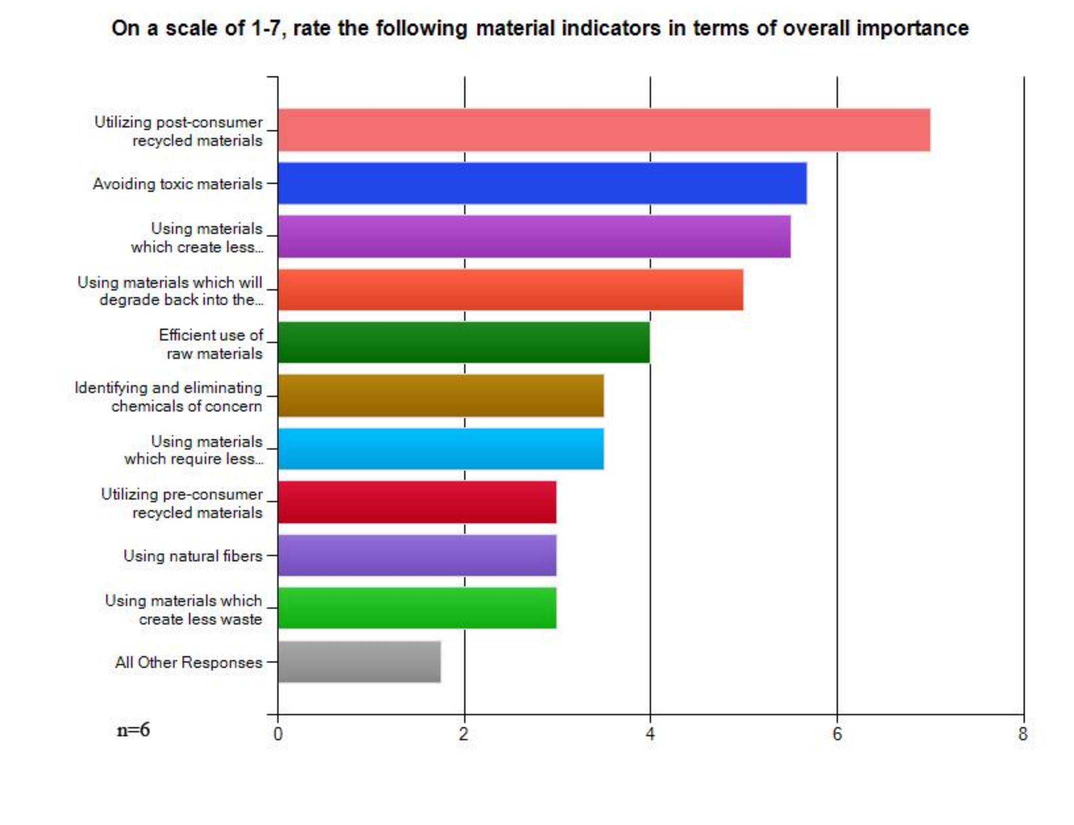

Figure 30: Materials indicators overall importance

Respondents were then asked to choose the top three most important indicators from the materials indicators provided.

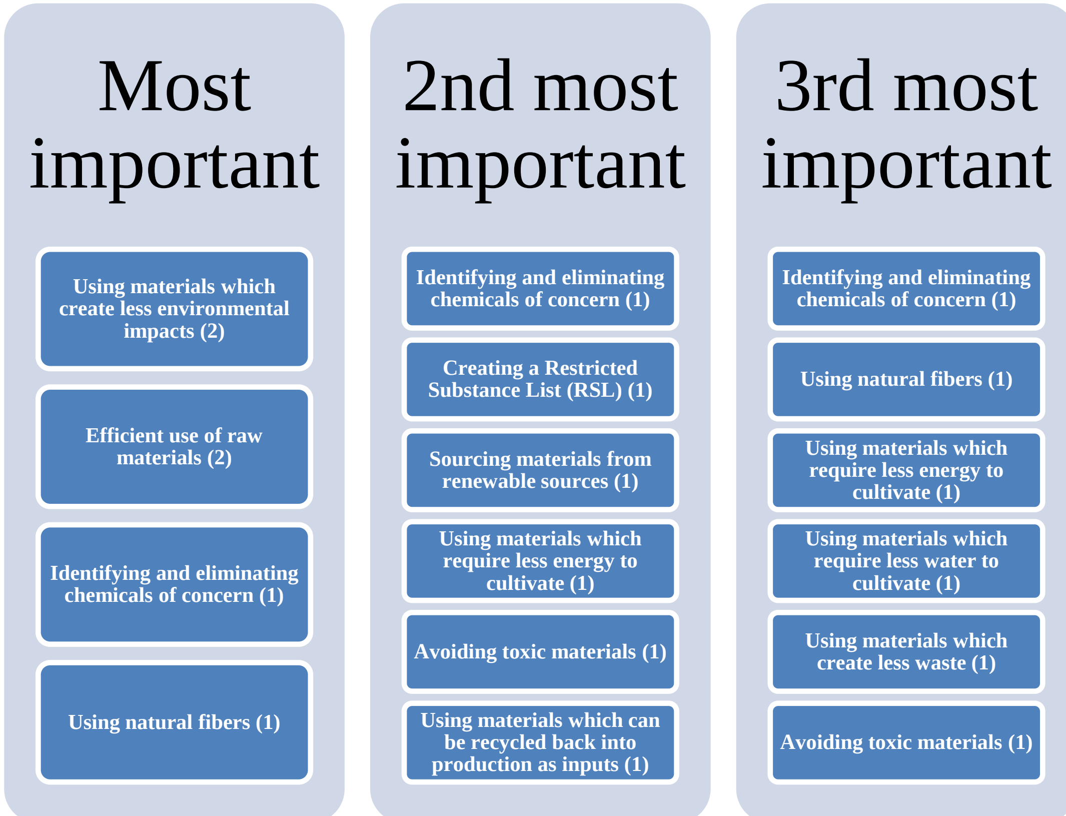

Figure 31: Forced ranked material indicators

To measure ease of implementation, respondents were asked to rank each materials indicator on a seven point semantic scale, 1 being easy to implement and 7 being difficult to implement. Respondents indicated **making Restricted Substance List available to the public** as the easiest indicator to implement with an average rating of 2.00 out of 7. **Utilizing pre-consumer recycled materials** was indicated as the second easiest indicator to implement, with an average rating of 3.00 out of 7. **Sourcing materials from renewable sources** also received an average rating of 3.00 out of 7. **Souring materials locally** was reported to be the most difficult indicator to implement, with an average rating of 5.33out of 7. Other indicators were ranked from easy to implement to difficult to implement as follows:

- **Using materials which require less water to cultivate** (average rating of 3.25 out of 7)
- **Creating a Restricted Substance List (RSL)** (average rating of 3.25 out of 7)
- **Using materials which create less waste** (average rating of 3.33 out of 7)
- **Efficient use of raw materials** (average rating of 3.33 out of 7)
- **Using materials which require less energy to cultivate** (average rating of 3.67 out of 7)
- **Utilizing post-consumer recycled materials** (average rating of 3.67 out of 7)
- **Identifying and eliminating chemicals of concern** (average rating of 4.00 out of 7)
- **Using certified organic fibers** (average rating of 4.00 out of 7**)**
- **Avoiding toxic materials** (average rating of 4.00 out of 7)
- **Using natural fibers** (average rating of 4.33 out of 7)
- **Using materials which create less environmental impacts** (average rating of 4.33 out of 7)
- **Using materials which can be recycled back into production as inputs** (average rating of 5.00 out of 7)
- **Using materials which will degrade back into the environment in less than 5 years after use** (average rating of 5.25 out of 7)

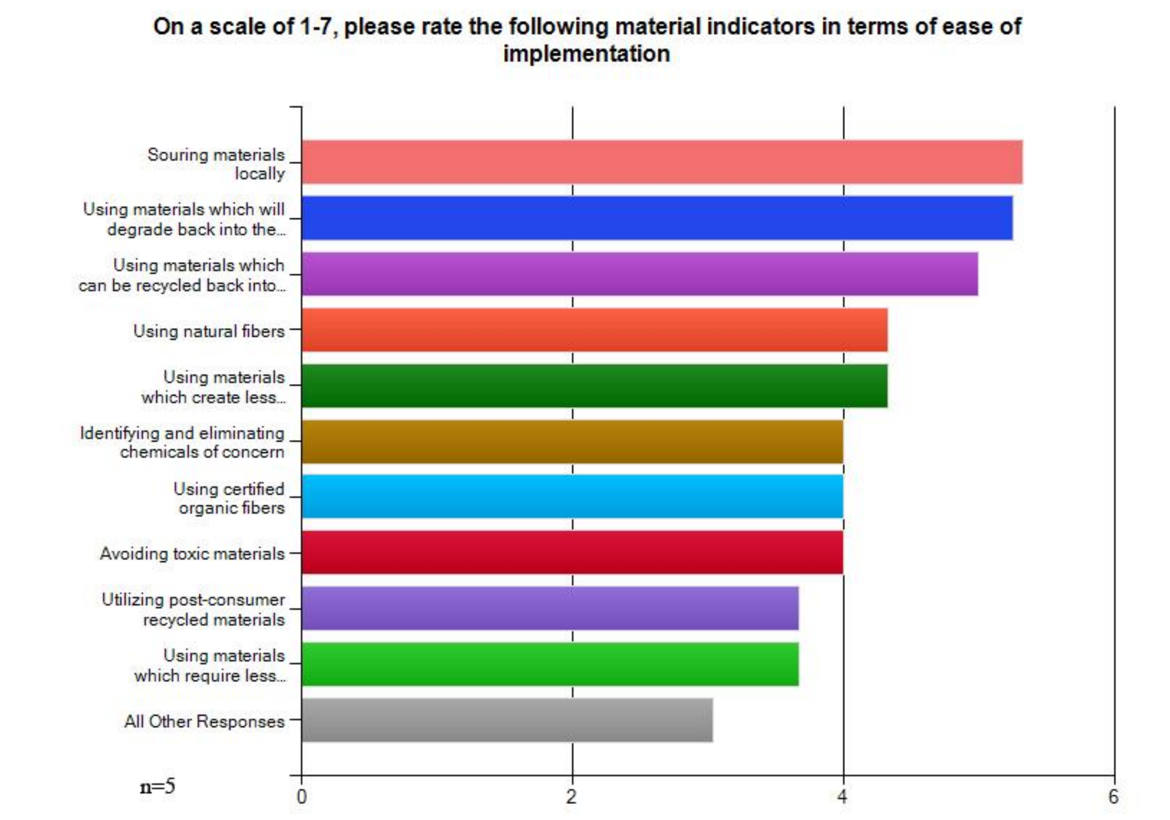

Figure 32: Material indicators ease of implementation

Use and aftercare

Of the 9 initial respondents, 6 indicated having less than one years of experience working with use and aftercare, while 1 indicated having one to three years of experience, 1 indicated having three to five years of experience, and 1 indicated having five or more years of experience with use and aftercare (See Figure 33).

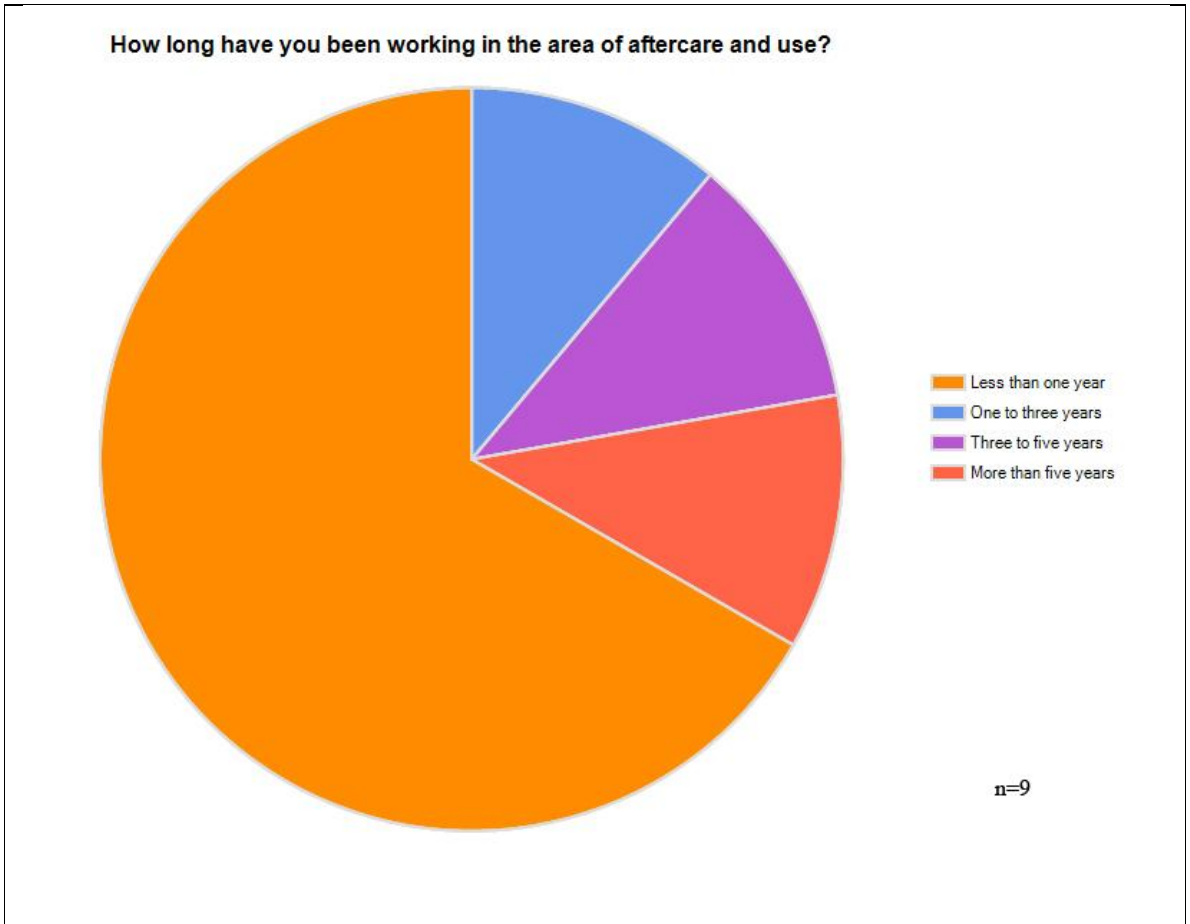

Figure 33: Aftercare and use experience

Respondents were then given an opportunity to list self-identified economic, social, and environmental issues relating to use and aftercare.

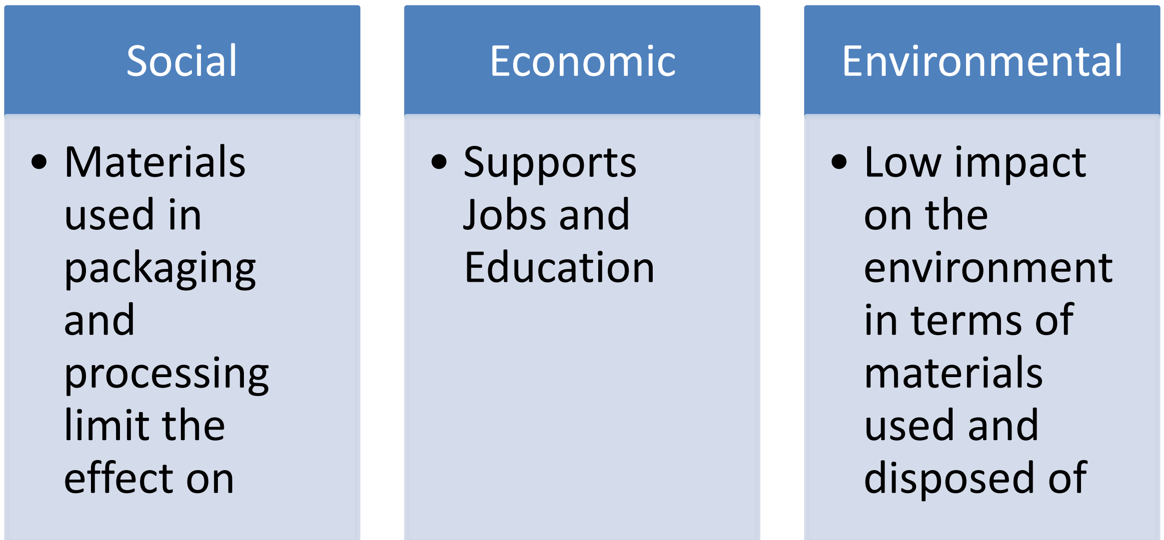

Figure 34: Self-identified issues of concern relating to aftercare and use

Respondents were then provided indicators which related to aftercare and use, and asked to rate them on a 7 point semantic differential scale in terms of overall importance. **End-of-life options are communicated to consumers** was identified as most important, and received an average rating of 6.50 out of 7. Respondents identified three indicators as being equally important. **Product is designed for durability and longevity, Product has a warranty, and high quality materials are used** all had an average rating of 4.50 out of 7. The least important aftercare and use indicator was **company offered product upgrades** with an average rating of 3.33 out of 7. Other indicators were ranked from least important to most important as follows:

- **Company offers repair/refurbishment services** (average rating of 3.67 out of 7)
- **Product is designed for low impact care and laundering** (average rating of 4.00 out of 7)

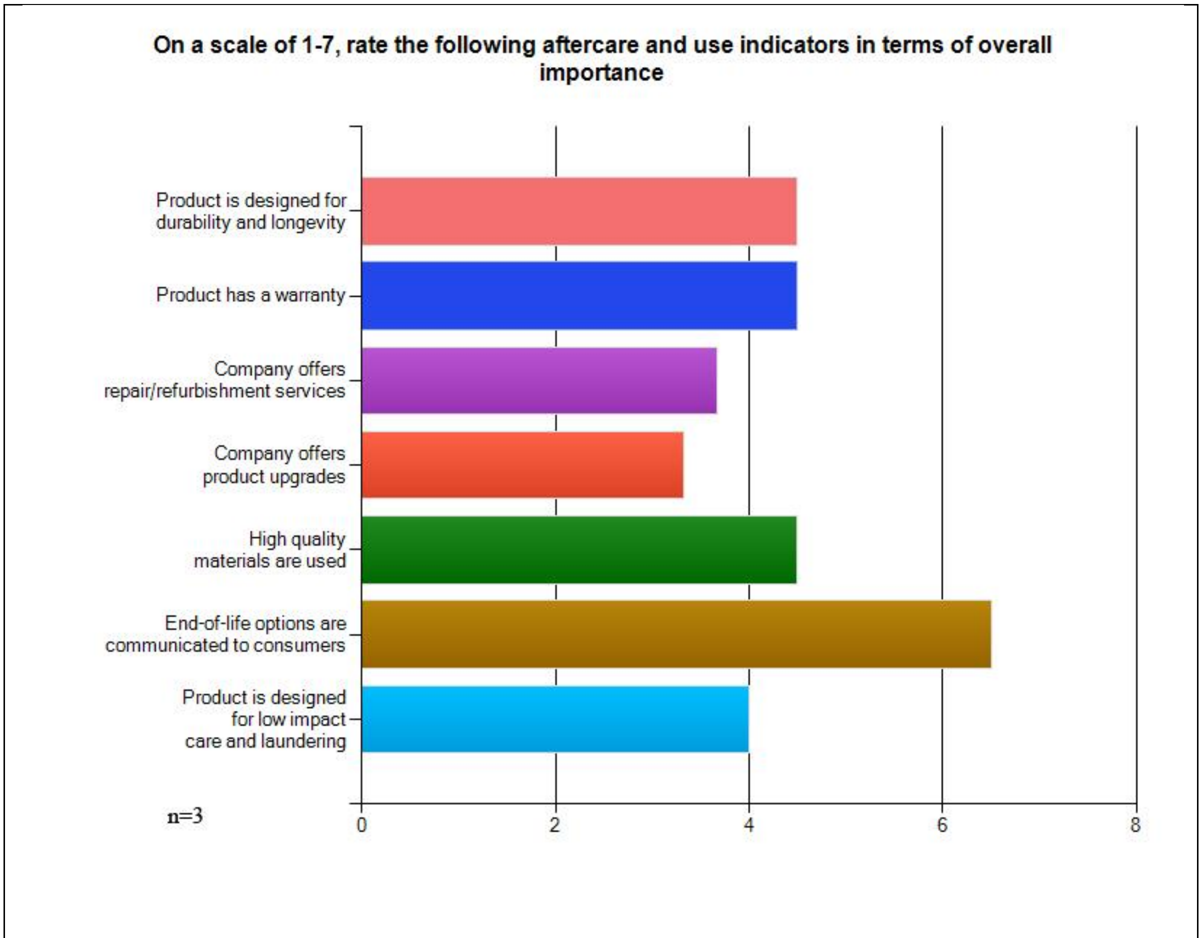

Figure 35: Aftercare and use indicators overall importance

Respondents were then asked to choose the top three most important indicators from the aftercare and use indicators provided.

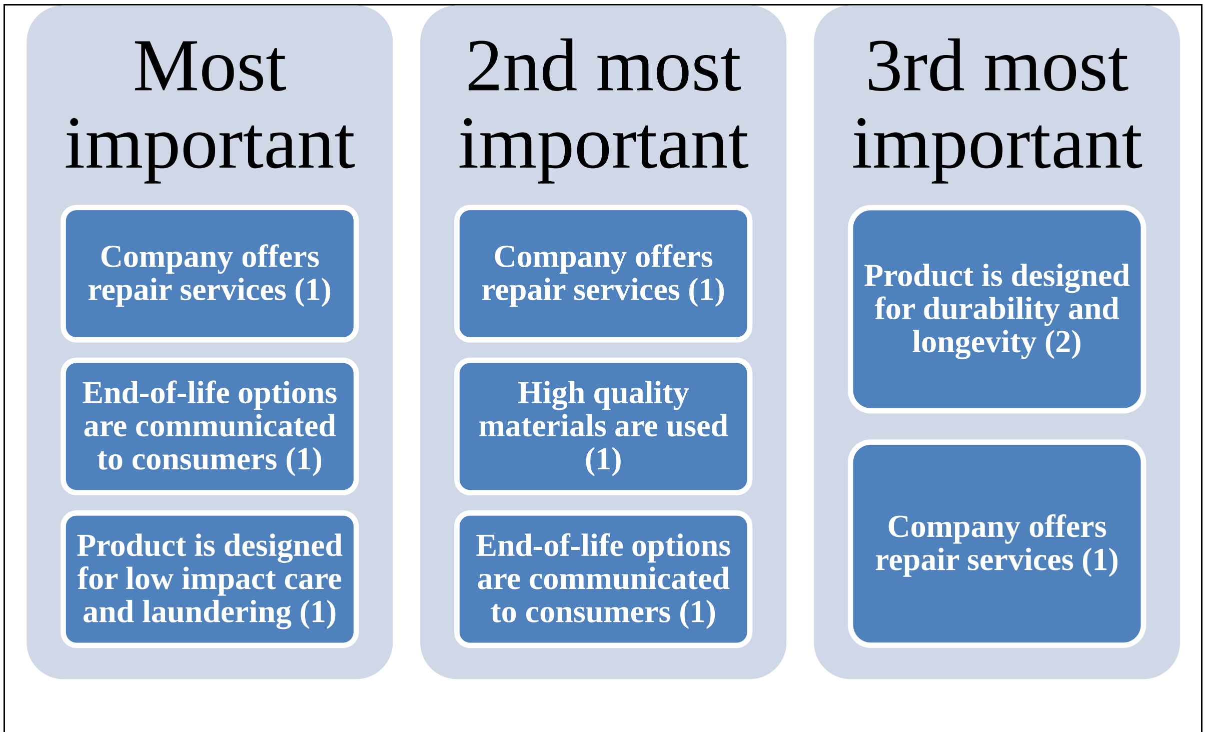

Figure 36: Forced ranked aftercare and use indicators

To measure ease of implementation, respondents were asked to rank each aftercare and use indicator on a seven point semantic scale, 1 being easy to implement and 7 being difficult to implement. Respondents indicated **end-of-life options communicated to consumers** as the easiest indicator to implement with an average rating of 2.00 out of 7. **Product is designed for durability and longevity** was indicated as the second easiest indicator to implement, with an average rating of 3.00 out of 7. Another indicator was also equally ranked as the second easiest indicator to implement with an average rating of 3.00 out of seven, **company offers a repair/refurbishment services. Company offered product upgrades** was reported to be the most difficult indicator to implement, with an average rating of 4.50 out of 7. Other indicators were ranked from easy to implement to difficult to implement as follows:

- **Product is designed for low impact care and laundering** (average rating of 3.50 out of 7)

- **High quality materials are used** (average rating of 4.00 out of 7)

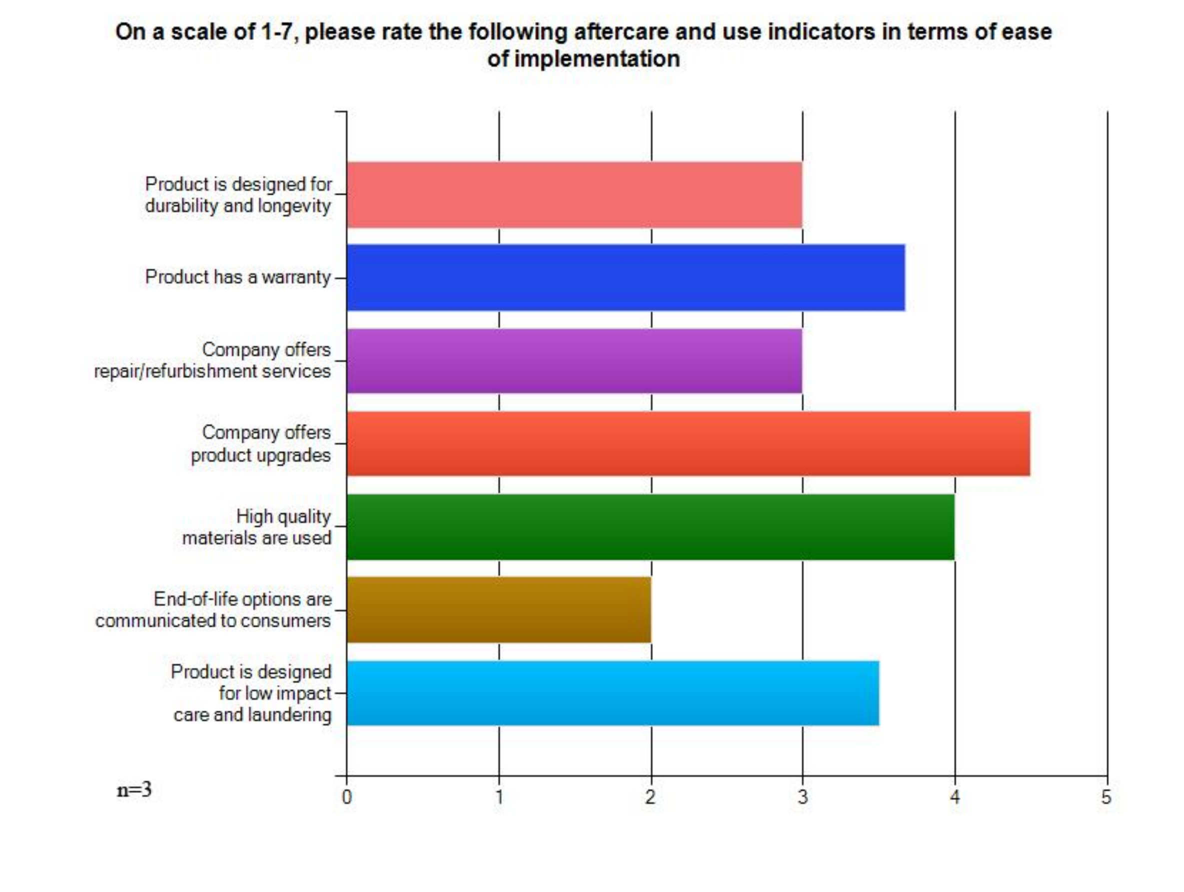

Figure 37: Aftercare and use indicators ease of implementation

Social Responsibility

Of the 9 initial respondents, 5 indicated having less than one years of experience working with social responsibility, while 2 indicated having one to three years of experience, 1 indicated having three to five years of experience, and 1 indicated having five or more years of experience with use and aftercare (See Figure 38).

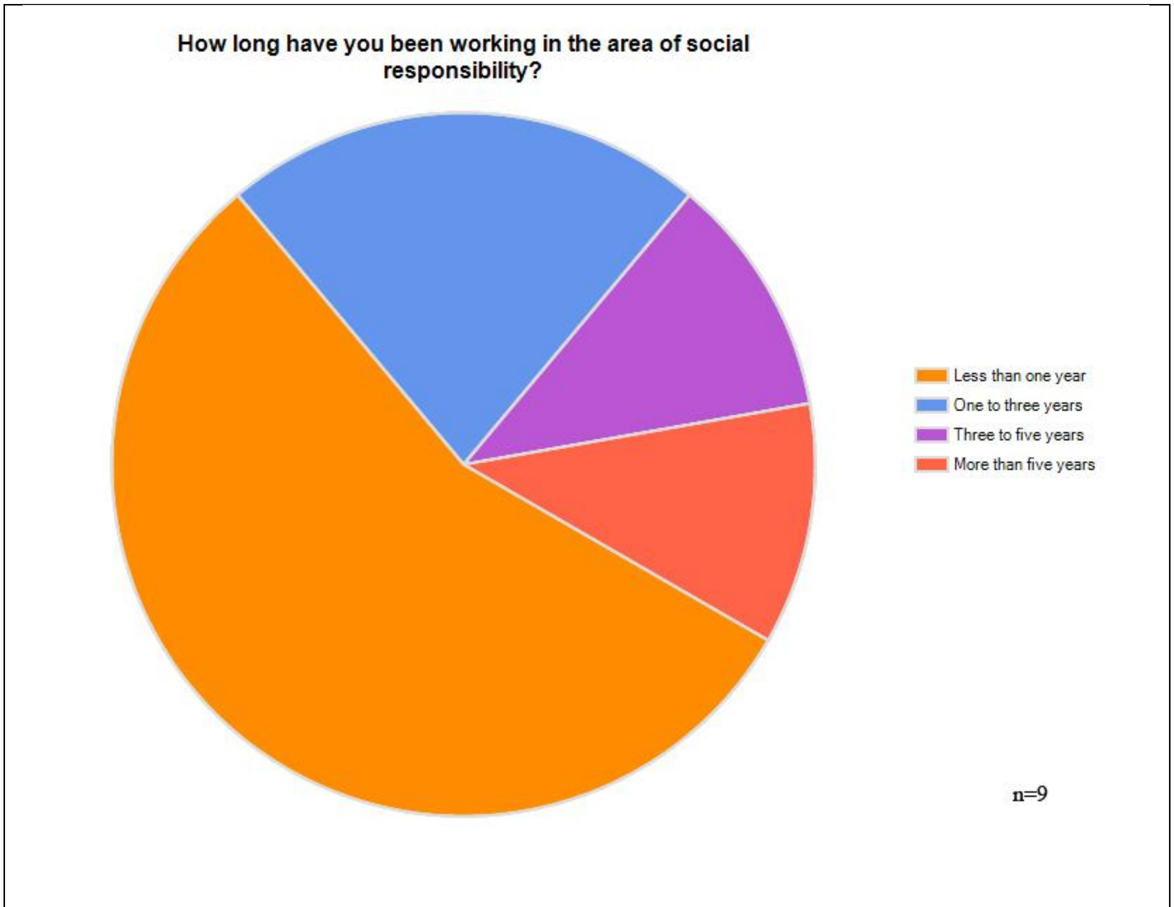

Figure 38: Social responsibility experience

Respondents were given an opportunity to list self-identified economic and environmental issues relating to use and aftercare.

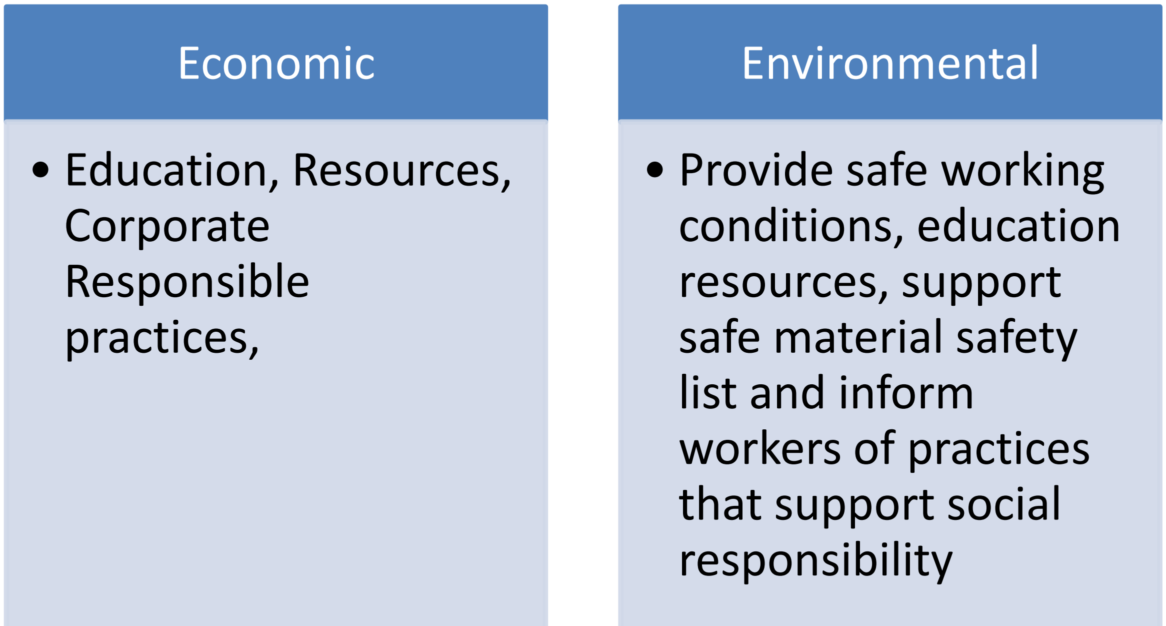

Figure 39: Self-identified issues of concern relating to social responsibility

Respondents were then provided indicators which related to social responsibility, and asked to rate them on a 7 point semantic differential scale in terms of overall importance. **Workers are trained** was identified as most important, and received an average rating of 7 out of 7. Respondents identified **employees being paid a livable wage** as the second most important indicator, with an average rating of 5.00 out of 7. **No use of child labor** and **company developed infrastructure and services for the public benefit** were rated equally as the third most important indicator, with an average rating of 4.50 out of 7. Two indicators, **employees have freedom of association and collective bargaining**, as well as **company has developed a corporate ethics/fair labor statement and made it publicly** available were rated equally as the least important social responsibility indicator with average ratings of 3.00 out of 7.00**.** Other indicators were ranked from least important to most important as follows:

- **Third party certification for social responsibility** (average rating of 3.25 out of 7)

- **Employment is freely chosen** (average rating of 3.33 out of 7)
- **Some senior management is hired from the local community** (average rating of 3.50 out of 7)

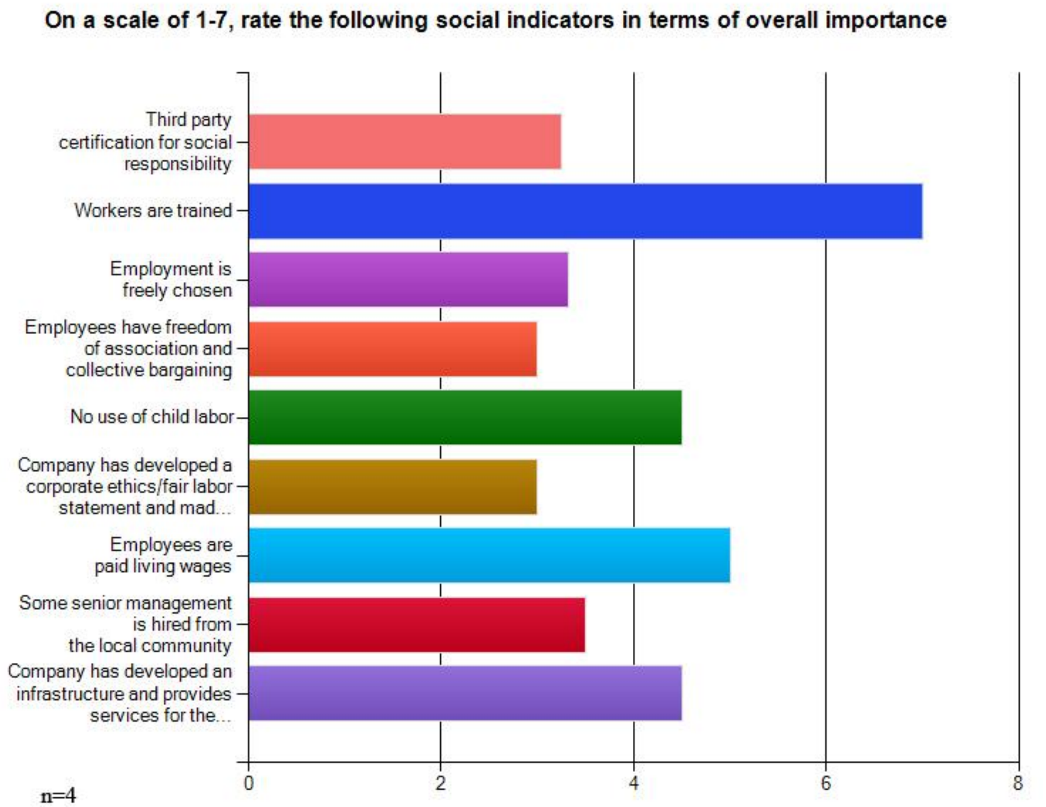

Figure 40: Social responsibility overall importance

Respondents were then asked to choose the top three most important indicators from the materials indicators provided.

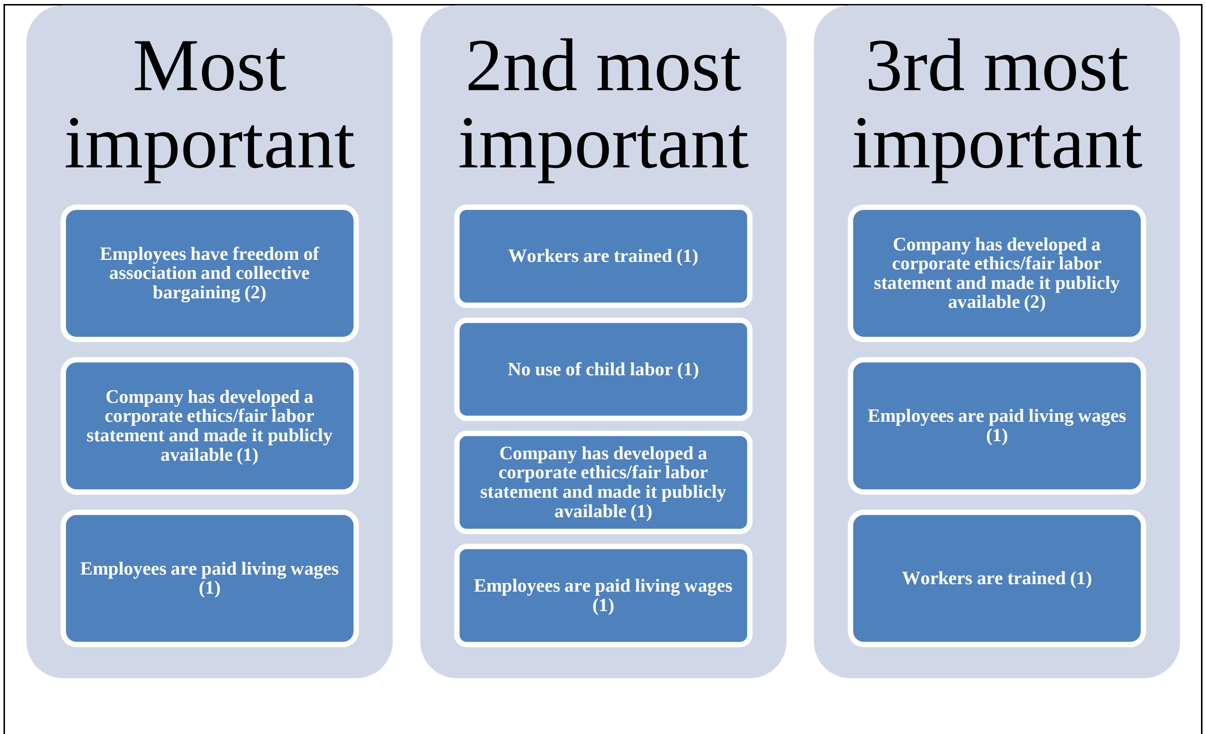

Figure 41: Forced ranked social responsibility indicators

To measure ease of implementation, respondents were asked to rank each social responsibility indicator on a seven point semantic scale, 1 being easy to implement and 7 being difficult to implement. Respondents indicated **No use of child labor** as the easiest indicator to implement with an average rating of 1.75 out of 7. **Employees are paid living wages** was indicated as the second easiest indicator to implement, with an average rating of 2.00 out of 7. Two indicators were ranked equally as the third easiest indicator to implement: **Employment is freely chosen** and **company has developed a corporate ethics/fair labor statement and made it publicly available**, both with average ratings of 3.00 out of 7. Two indicators were also ranked equally for most difficult to implement: **Workers are trained** and **company has developed an infrastructure and provides series for the public benefit**, both with an average rating of 4.50 out of 7. Other indicators were ranked from easy to implement to difficult to implement as follows:

- **Employees have freedom of association and collective bargaining** (average rating of 3.50 out of 7)
- **Some senior management is hired from the local community** (average rating of 3.50 out of 7)
- **Third party certification for social responsibility** (average rating of 4.00 out of 7)

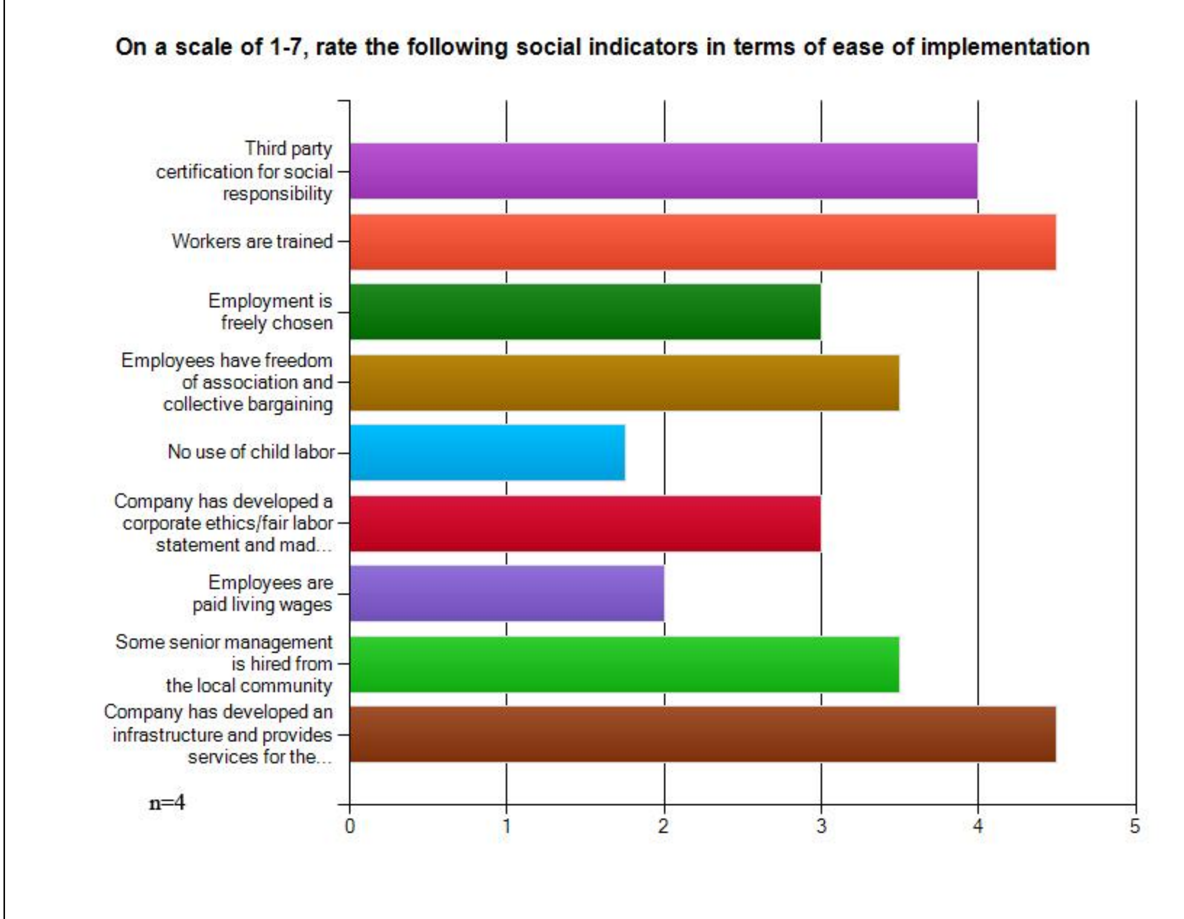

Figure 42: Social responsibility indicators ease of implementation

Chapter V

Discussion, Limitations, and Recommendations

Discussion

Company overview and activities

Largely, companies were producing, designing, and/or retailing sustainable, green, eco-friendly, or environmentally friendly products which were made from recycled material (68.8%), made to be recycled (56.3%), or organic (37.5%). Efforts to incorporate sustainability into producing, designing, and/or retailing products were largely environmentally based efforts. Only 18.8 % of respondents reported producing, designing, or retailing fair trade products, which may predominately have a social impact.

Many respondents (61.1%) reported not seeking third party certifications. This may be related to the large amount of firms focusing on integrating recycled materials into their products, for which a self-declared environmental claim may be appropriate than a third party endorsement. Of the third party certifications which respondents were currently endorsed by or working towards, many were oriented towards certified organic products, including the USDA National Organic Program and Global Organic Textile Standard (GOTS).

End-of-life

Three end-of-life indicators came up repeatedly in both the semantic rating scale, as well as the forced ranking. Designing a product to be reused, refilled, or repurposed was averagely rated as the most important end-of-life indicator, and was also ranked highly in the forced ranking option. Identifiable material components were ranked as the second most important indicator on the semantic scale, and as the most important indicator in the forced ranking option. Designing a product to be recycled also was ranked highly on the semantic scale as well as the forced ranking question.

Identifiable material components was also ranked as the easiest to implement, which may make it ideal as an indicator which may be required in order to promote your product as sustainable. Creating product with identifiable material components also has great implications on design for recycling. Although the US requires fibers to be labeled on garments, this does not necessarily include trimming, facing, interfacing, threads, and non-textile components, such as buttons, zippers, and other closures. Unknown and unidentifiable components can create limitations when trying to recycle a product and creating a ‘product map’ or another traceable marker on components will ease and promote recycling.

Although many respondents indicated producing, designing, and retailing products which could be recycled (56.3%), many ranked indicators directly affecting the recyclability of a product as fairly unimportant. Designing a product to be easily disassembled received an average rating of 4.64 out of 7, and avoiding blended materials received an average rating of 4.36 out of 7. Both of these indicators directly affect a products ability to be easily recycled. Designing a product to be reused, refilled, or re-purposed received the highest average rating of overall importance, 5.45 out of 7, although only 25% percent of respondents indicated designing, producing, or retailing a reusable product.

Overall, there was not a lot of variation between the degrees of importance for end-of-life indicators. All nine indicators had an average rating between 4.18 and 5.45 out of 7. None of the end-of-life indicators were also listed averagely rated as extremely important. None of the indicators received above a 6 as an average rating. Similarly, none of the end-of-life indicators were rated as easy to implement. All nine indicators were averagely rated between 2.91 and 4.80 out of 7.

Processing and manufacturing

Most of the processing and manufacturing indicators were averagely rated fairly high in terms of overall importance. Most of the processing and manufacturing indicators are directly related to environmental issues, and impacts related to these indicators are often easy to understand and see. This may be the cause of these particular set of indicators being rated as more important than other sets of indicators. Most processing and manufacturing indicators were between 5.10 and 6.10 out of 7. Only two indicators were averagely rated below 5.0: the company having a plan to minimize number of production methods and operations (4.27) and company measuring solid waste at facility (4.80). Of the processing and manufacturing indicators, two indicators were averagely rated at 6.10: company measures energy use at facility, and company measure hazardous waste generated at facility. Although there was not a lot of variation between the processing and manufacturing indicators, when respondents were forced to choose the top three most important indicators, more than half (63.7%) chose two indicators as the most important: company has developed an environmental management system at facility (36.4%) and company has a plan to reduce energy use at facility (27.3%). Developing an environmental management system may address numerous issues, such as water and energy use, as well as solid waste, hazardous waste, air emissions, and wastewater emissions, which may explain why it was ranked as most important. Although it received high ratings in terms of overall importance, it was also averagely rated as the most difficult to implement, with an average rating of 4.70 out of 7. The two processing and manufacturing indicators rated as easiest to implement included measuring energy and water use at facilities (2.90 and 2.60 out of 7). Similar to other sets of indicators, none of respondents rated any processing and manufacturing indicators as extremely easy to implement. All processing and manufacturing indicators received average ratings between 2.60 and 4.70 out of 7 in terms of ease of implementation. The two indicators which may lend themselves to being requirements are measuring energy and water at facilities, as both indicators were rated of high importance, and relatively easy to implement.

Packaging and distribution

Respondents indicated Company use of an efficient transport system as the most important indicator, with an average rating of 4.83 out of 7. Similar to other sets of indicators, none of the packaging and distribution indicators were rated very high in overall importance, and there was not a lot of variation between indicators. All 8 indicators received average ratings between 3.17 and 4.83. Aside from efficient transportation, respondents rated packaging which is designed to be reuse, and minimizing packaging and product weight as relatively important (both indicators received average ratings of 4.71 out of 7). Packaging sourced from certified and traceable sources was averagely rated as the least important indicator, with an average rating of 3.17 out of 7. There was not a lot of agreement when respondents were asked to choose the three most important packaging and distribution indicators. 28.6% specified the most important indicator was for company to develop or adopt a Packaging Restricted Substance List (PRSL). Other indicators were ranked equally as the most important (14.3%), including use of post-consumer recycled content in packaging, minimizing packaging material, designing packaging material to be recycled or reused, and the use of an efficient transport system. There was not a lot of variation in terms of ease of implementation of packaging and distribution indicators either. The easiest indicator to implement (average rating of 2.20) was the use of an efficient transport system. This may be due to the cost advantages of transport systems typically considered environmentally efficient, such as boat or rail transport. The most difficult indicator to implement was packaging designed to be reused (average rating of 4.00 out of 7).

Because the use of an efficient transport system was averagely rated high in both overall importance and ease of implementation, it may be an ideal indicator for requirement in terms of promoting your firm or product as sustainable.

Materials

Material indicators were the least agreed upon set of indicators. When respondents were asked to choose top three most important indicators, two indicators were chosen equally (33.3%) as the most important: efficient use of raw materials and using materials which create less environmental impacts. Other indicators ranked as most important were identifying and eliminating materials of concern (16.7%), as well as using natural fibers (16.7%). Virtually none of the material indicators agree upon consensus in terms of overall importance. None of the indicators were ranked as extremely easy to implement. Making a Restricted Substance List available to the public was averagely rated as the easiest to implement, but was also rated very low in terms of overall importance. Sourcing materials locally was rated as the most difficult to implement, with an average rating of 5.33 out of 7.

Although many respondents indicated producing products made from recycled materials, none ranked utilizing post- or pre-consumer recycled materials as important. Similarly, although many respondents reported producing, designing, or retailing organic products, none listed using certified organic fibers as important. Only 16.7% of respondents ranked using materials which can be recycled back into product as inputs in their top three most important indicators. Although many respondents seem to be concentrated on producing products that are made from recycled materials, recyclable, or organic, none seemed to think of these indicators as overall very important. Efficient use of raw materials was ranked as one of the most important indicators, which may be related to the economic impact efficient use implies.

Because there was not a large amount of agreement from respondents concerning material indicators, more research may need to be performed in this area before choosing required indicators.

Aftercare and use

Only one aftercare and use indicator was ranked of high importance: communicating end-of-life options to consumers, which received an average rating of 6.50 out of 7. No other aftercare and use indicator received a very high average rating of importance. When forced to choose top three most important indicators, there was disagreement between respondents. Three indicators were ranked equally for most important: end-of-life options are communicated to consumers, product is designed for low impact care and laundering, and company offers repair services. Other indicators listed as in the top three most important were use of high quality materials and product is designed for durability and longevity. The only aftercare and use indicator rated as relatively easy to implement was communicating end-of-life options to consumers, which when combined with its high rating of overall importance, may make it justifiable as a requirement for a firm or product to be considered sustainable.

Social Responsibility

Respondents ranked five of the 9 social responsibility indicators in the top 3 most important considerations. Employee's freedom of association and collective bargaining was ranked as the most important (50%), along with the company developing a corporate ethics/fair labor statement and making it publicly available, as well as employees being paid livable wages. Ranked in the second and third most important indicators were training workers and no use of child labor. Only one indicator was averagely rated as easy to implement, which was no use of child labor, which received an average rating of 1.75 out of 7. Training workers and company developing an infrastructure and providing services for the public benefit were ranked as the most difficult to implement, with average ratings of 4.50 out of 7.

No use of child labor was ranked as the easiest to implement, and also in the top three most important indicators, which may make it suitable as a requirement for a firm or product to be considered sustainable.

Limitations

There were several limitations associated with this study.

- Participation- 53 individuals were contacted directly to participate in the study, and 12 more were contacted to participate as well as forward the survey to other known experts in the field of sustainability to complete. Only 27 individuals participated in the study. The researcher believes this may be due to the time constraints of the participants.
- Time- There was a very limited amount of time in which this research could be conducted. The lack of available time limited the depth in which certain topics could be covered. Additionally, more time would have allowed for a more comprehensive research methodology, where focus groups or in-depth surveys could have been conducted.
- Bias- Although the sample population represented general experts in the area of sustainability for the textile and apparel industry, participants may have bias associated with their answers due to the activities in which their company participates.
- Sampling methodology- The sampling methodology was conducted similar to the sampling methodology in a typical Delphi study. The sample population was a target population of experts, practitioners, and experienced individuals in the general field of sustainability in the textile and apparel industry. This target population was a combination of a non-probability judgment sample as well as a partial snowball sample. Participants were selected in hopes of obtaining the most insight into the topic of interest. The initial participants were chosen

based on contacts made by the primary researcher, or secondary researchers, at conferences, workshops, meetings, or previous associations. There is a possibility that this sampling methodology did not include a complete representation of all critical members in the textile and apparel industry.

Recommendations

The researcher recommends that industry work together to help further define and implement a foundation for which firms and products must meet in order to be marketed and promoted as sustainable. Because sustainability does not yet have a generally accepted definition, firms are participating in very different activities to integrate sustainability into their business practice and products. It is possible that firms are not participating in basic activities which have been generally agreed upon as the basis for making claims of sustainability for firms and products. New companies, new products, and existing companies interested in implementing sustainability into their business practices and products should use research findings to understand which activities represent the most meaningful actions, and act as building blocks from which further initiatives can be based upon.

The researcher also recommends creating a web-based tool based off of research findings for which designers can map and measure the sustainability of textile and apparel products. Providing a tool for designers to visually depict the impacts of their design decisions will allow for more informed choices concerning the economic, environmental, and social impacts of products.

REFERENCES

Allwood, J. M., Laursen, S. E., Rodriguez, C. M., & Bocken, N. M. (2006). *Well dressed? the present and future sustainability of clothing and textiles in the united kingdom*. Great Britain: University of Cambridge Institute for Manufacturing. Grizzle, 2003

American Apparel and Footwear Association (2010). *American apparel and footwear association.* Retrieved 7/25/2010, 2010, from http://www.apparelandfootwear.org/

American Apparel and Footwear Association. (2008). *Trends: An annual statistical analysis of the U.S. apparel & footwear industries*. Arlington, VA: American Apparel and Footwear Association.

Ayres, R. U. (1995). Life cycle analysis: A critique. *Resources, Conservation and Recycling, 14*(3-4), 199-223.

Baird, N., & Rowen, S. (2010). *Lean and green: How sustainable practices are changing retail.* RSR Research.

Bartl, A. (2008). *Fiber recycling: Potential for saving energy and resources*. Vienna, Austria: Vienna University of Technology - Institute of Chemical Engineering.

Bartl, A., & Marini, I. (2006). *Recycling of apparel*. Vienna, Austria: Vienna University of Technology –Institute of Chemical Engineering.

Baugh, G. (2008). Fibers: Clean and green fiber optics. In J. Hethorn, & C. Ulasewicz (Eds.), *Sustainable fashion, why now?: A conversation about issues, practices, and possibilities* (pp. 326-357). New York: Fairchild books, inc.

Belk, R. W. (1988). Possessions and the extended self. *The Journal of Consumer Research, 15*(2), 139-168. Retrieved from http://www.jstor.org/stable/2489522

Belletire, S., Pierre, L., & White, P. (2007). *Okala: Learning ecological design.* Unpublished manuscript.

Boswell, C. (2010). Closing the loop. *ICIS Chemical Business, 277*(17), 22-24.

Braungart, M., McDonough, W., & Bollinger, A. (2007). Cradle-to-cradle design: Creating healthy emissions – a strategy for eco-effective product and system design. *Journal of Cleaner Production, 15*(13-14), 1337-1348. doi:DOI: 10.1016/j.jclepro.2006.08.003 Ljungberg, 2005

Bureau of International Recycling. *Textiles.* Retrieved October 12, 2010, from http://www.bir.org/industry/textiles/

Center for Remanufacturing and Reuse. (2010). *Case example from the sustainable clothing action plan.* Retrieved 10/11/2010, 2010, from http://www.defra.gov.uk/environment/business/products/roadmaps/documents/crr-0910-case-study.pdf.

Centre for Remanufacturing and Reuse. (n.d.). *Remanufacturing & Reuse*. Retrieved 10/15/2010, 2010, from http://www.remanufacturing.org.uk/reuse-repair-recycle.lasso.

Change, Y., Chen, H., & Francis, S. (1999). Market applications for recycled postconsumer fibers. *Family and Consumer Sciences Research Journal*, *27*(3), 320-340.

Chapagain, A. K., Hoekstra, A. Y., Savenije, H. H. G., & Gautam.R. (2005). *The water footprint of cotton consumption* No. 18). Netherlands: UNESCO-IHE Institute for Water Education. Berichte, 2010

Chen, H., & Burns, L. D. (2006). Environmental analysis of textile products. *Clothing and Textiles Research Journal*, *24*(3), 248-261. doi:10.1177/0887302X06293065

Cooper, T. (2005). Slower consumption: Reflections on product life spans and the "throwaway society". *Journal of Industrial Ecology*, *9*(1), 51-67.

DEFRA. (2006). *e-digest environmental statistics, waste and recycling.* Retrieved October 22, 2010, 2011, from http://www.defra.gov.uk/evidence/statistics/environment/waste/kf/wrkf09.htm

EcoTextiles News. (2010). *Levi's develops reduced water denim.* Retrieved 12/7/2010, 2010, from http://ecotextilenews.com/index.php?option=com_content&view=article&id=10869:levis-develops-reduced-water-denim&catid=112:materials-production-premium&Itemid=2

Ehrenfeld, J. R. (1997). The importance of LCAs? Warts and all. *Journal of Industrial Ecology, 1*(2), 41-49.

El-Nouby, G. M., Azzam, H. A., Mohamed, S. T., & El-Sheikh, M. N. (2005). Textile waste-material recycling part I: Ways and means. *Textile Processing: State of the Art & Future Developments, 2*(5), 394-407.

Ergas, S. J., Therriault, B. M., & Reckhow, D. A. (2006). Evaluation of water reuse technologies for the textile industry. *Journal of Environmental Engineering, 132*(3), 315-323.

European Commission (2003), Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Textile Industry, Brussels: European Commission, i-221.

Farrant, L., Olsen, S. I., & Wangel, A. (2009). Environmental benefits from reusing clothes. *The International Journal of Life Cycle Assessment,* 15(7), 726-736.

Fletcher, K. (2008). *Sustainable fashion & textiles*. London, UK: Earthscan.

Fletcher, K. (2009). Systems change for sustainability in textiles. *Sustainable textiles: Life cycle and environmental impact* (pp. 369-380). Cambridge, UK: Woodhead Publishing in Textiles.

Fletcher, K., Dewberry, E. (2002). Demi: a case study in design for sustainability. *International journal of Sustainability in Higher Education*, 3(1), 38-47.

Fletcher, K., Goggin, P., (2001). The Dominant Stances on Ecodesing: A Critique. *Design Issues,* 17(3), 15-25.

Fraser, K. (2009). ReDress: Refashion as a solution for clothing (un) sustainability. (Master of Art and Design, AUT University). , 1-78.

Goodwill Industries International, Inc. (2010). *Goodwill industries international, inc.* Retrieved 2/7/2011, 2011, from http://www.goodwill.org/

Grasso, M. (1996). Recycling fabric waste-the challenge industry. *Journal of the Texxtile Institute, 87*(1), 21-30.

Guide Jr. ,V.Daniel R., Harrison, T. P., & Van Wassenhove, L. N. (2003). The challenge of closed-loop supply chains. *Interfaces, 33*(6), 3-6. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=12272256&site=ehost-live&scope=site

Gulich, B. (2006). The design of easy to recycle textile products. In Y. Wang (Ed.), *Recycling in textiles* (pp. 25-47). Cambridge, UK: Woodhead Publishing in Textiles.

Haggblade, S. (1990). The flip side of fashion: Used clothing exports to the third world. *Journal of Development Studies, 26*(3), 505. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=7146221&site=ehost-live&scope=site.

Hawley, J. (2009). Understanding and improving textile recycling: A systems perspective. In R. S. Blackburn (Ed.), *Sustainable textiles: Life cycle and environmental impact* (pp. 179-199). Cambridge, UK: Woodhead Publishing in Textiles.

Hawley, J. M. (2006). Digging for diamonds: A conceptual framework for understanding reclaimed textile products. *Clothing and Textiles Research Journal, 24*(3), 262-275.

Hoekstra, A. Y., & Hung, P. Q. (2002). *VIRTUAL WATER TRADE: A QUANTIFICATION OF VIRTUAL WATER FLOWS BETWEEN NATIONS IN RELATION TO INTERNATIONAL CROP TRADE* No. 11. The Netherlands: IHE Delft.

Huppes, G., van Rooijen, M., Kleijn, R., Heijungs, R., de Koning, A., & van Oers, L. (2004). *Life cycle costing and the environment* No. 200307074.

International Organization for Standardization (2006). *Environmental Management — Life Cycle Assessment — Principles and Framework ISO 14040.*

International Trade Centre. (2010). *Trade map- List of products exported by United States of America.* Retrieved 09/29/2010, 2010, fromhttp://www.trademap.org/textile/Product_SelCountry_TS.aspx.
International working group on global organic textile standard. (2005). *Global organic textile standard version 1.1* No. 1.
Junky Styling. (2010). *Junky styling.* Retrieved 10/15, 2010, from http://www.junkystyling.co.uk/
Koch, K., & Domina, T. (1997). The effects of environmental attitude and fashion opinion leadership on textile recycling in the US. *Journal of Consumer Studies and Home Economics*, *28*(1), 3-7.
Koch, K., & Domina, T. (1999). Consumer textile recycling as a means of solid waste reduction. *Family and Consumer Sciences Research Journal, 28*(1), 3-17.
Looptworks. (2010). *LooptWorks- 100% upcycled clothing uniquely created from excess.* Retrieved 10/7/2010, 2010 from http://www.looptworks.com/.
Martins, A. A., Mata, T. M., & Costa, C. A. V. (2007). Framework for sustainability metrics. *Industrial & Engineering Chemistry Research, 46*(10), 2962-2973.
McDonough Braungart Design Chemistry. (2010). *MBDC | cradle to cradle design* Retrieved 9/15/2010, 2010, from http://mbdc.com/.
McDonough, W., & Braungart, M. (2002). *Cradle to cradle: Remaking the way we make things*. New York, NY: North point press.
Moore, S. B., & Wentz, M. (2009). Eco-labeling for textiles and apparel. In R. S. Blackburn (Ed.), *Sustainable textiles: Life cycle and environmental impact* (pp. 214-230). Cambridge, UK: Woodhead Publishing in Textiles.
Morana, R., & Seuring, S. (2003). Organizing a closed loop supply chain for used textiles—The ECOLOG case study. *Strategy and organization in supply chains* (pp. 369-384) Physica-Verglag.
New York City Department of Sanitation. (2005). *The new york city 2004-05 residential and street basket waste characterization study* No. 1.
Niinmaki, K. (2009). Consumer values and eco-fashion in the future. *Future of the Consumer Society,* Tampere, Finland.
Nike Inc. (2009). *Nikebiz : NIKE, inc. official site, the world's largest, leading athletic brand.* Retrieved 11/20/2010, 2010, from http://www.nikebiz.com/.
NPD Group. (2010). *Apparel Market Monitor.* Retrieved from http://www.NPD.com/.
Oerlikon Corporation. (2010). *The fiber year 2009/2010: A world survey on textiles and nonwovens industry* No. 10)
Oliva, R., & Quinn, J. (2003). Interface's evergreen services agreement. *Harvard Business School Cases*, 1-20.
O'Neil, G. (2010). Environmentally sustainable textile manufacturing: Is it achievable? *ITT Sustainability Workshop,* Raleigh, N.C.
Organic exchange. (n.d.). *Making informed choices: Sustainable fibers*
Orzada, B., & Moore, M. A. (2008). Environmental impact of textile production. In J. Hethorn, & C. Ulasewicz (Eds.), *Sustainable fashion, why now?: A conversation about issues, practices, and possibilities* (pp. 299-325). New York: Fairchild books, inc.
Patagonia. (n.d). Patagonia's Common Threads Garment Recycling Program: A Detailed Analysis. Retrieved from http://www.patagonia.com/pdf/en_US/common_threads_whitepaper.pdf
Patagonia. (n.d.). *Customer Service: Repairs& Returns.* Retrieved from http://www.patagonia.com/us/patagonia.go?assetid=5175&ln=74.

Patterson, P. (2011). *REACH for dummies.* Retrieved January 26, 2011, from http://www.ecotextile.com/index.php?option=com_content&view=article&id=10783:reach-for-dummies&catid=111:labels-legislation-premium&Itemid=2

Platt, B. (1997). *Weaving textile reuse into waste reduction.* Institute for Local Self-Reliance.

Portney, P. R. (1993). The price is right: Making use of life cycle analyses. *Issues in Science & Technology*, *10*(2), 69. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=9406220163&site=ehost-live&scope=site

Rahimifard, S., Staikos, T., & Coates, G. (2007). *Recycling of footwear products: A position paper prepared by the centre for sustainable manufacturing and Reuse/recycling technologies (SMART)*. Leicestershire, UK: Loughborough University.

REACH UK Competent Authority. (2009). *Substances of very high concern*. No. 12.

Resource Recovery Forum. (2004). *Remanufacturing in the UK: A significant contributor to sustainable development?*. Aylesbury UK: Oakdene Hollins Ltd.

Richins, M. L. (1994). Valuing things: The public and private meanings of possessions. *Journal of Consumer Research*, *21*(3), 504-521.

Roy, R. (2000). Sustainable product-service systems. *Futures, 32*(3-4), 289-299.

Salvation Army Trading Company Ltd. (2010). *Textiles and Clothes Recycling.* Retrieved from http://www.wear2bank.co.uk/Clothing-Collection-Scheme/Clothing-Banks.

Scientific Applications International Corporation. (2006). *Life cycle assessment: Principles and practice* No. EPA/600/R-06/06). Cincinnati, Ohio: U.S. Environmental Protection Agency.

Secondary Materials and Recycled Textiles Association. (n.d.). *Textile recycling in the changing global market.* Secondary Materials and Recycled Textiles Association. Retrieved from http://smartech.gatech.edu/bitstream/handle/1853/10364/4th%20-%2010%20bril.pdf;jsessionid=303CCCEE28011CBE029DF3C9FE6CD165.smart1?sequence=1.

Seitz, M. A., & Peattie, K. (2004). Meeting the closed-loop challenge: The case of remanufacturing. *California Management Review, 46*(2), 74-89.

Sherburne, A. (2009). Achieving sustainable textiles: A designer's perspective. *Sustainable textiles: Life cycle and environmental impact* (pp. 3-32). Cambridge, UK: Woodhead publishing in textiles.

Shim, S. (1995). Environmentalism and consumer’s clothing disposal patterns: An exploratory study. *Clothing and Textile Research Journal*, *13*(1), 38-48.

Sproles, G. B. (1981). Analyzing fashion life cycles: Principles and perspectives. *The Journal of Marketing, 45*(4), 116-124. Retrieved from http://www.jstor.org/stable/1251479

Sroufe, R., Curkovic, S., Montabon, F., & Melnyk, S. A. (2000). The new product design process and design for environment: “Crossing the chasm”. *International Journal of Operations & Production Management, 20*(2), 267-291.

Storey, H., Ryan, T. & Interface. (2005). *Wonderland.* Retrieved October/25, 2010, from

Swinker, M. E., & Hines, J. D. (2006). Understanding consumers' perception of clothing quality: A multidimensional approach. *International Journal of Consumer Studies, 30*(2), 218-223. doi:10.1111/j.1470-6431.2005.00478.x

Textile Recycling for Aid and International Development. (n.d.). *TRIAD. Textile Recycling for Aid and International Development.* Retrieved 10/25/2010, 2010, from http://www.traid.org.uk/.

Thiry, M. (2005). The marketing and certification of sustainable textiles. *AATCC Review,* (March), 7-12.

Thiry, M. (2007). If the environment is important. *AATCC Review,* (May), 21-28.

Thiry, M. (2010). Color it greener. *AATCC Review*, (May/June), 32-39.
Trans America Trading Company. (2010). *Trans-America trading co. - secondhand used and vintage clothing* Retrieved 10/15/2010, 2010, from http://www.tranclo.com/.
Ulaga, W., & Chacour, S. (2001). Measuring customer-perceived value in business markets: A prerequisite for marketing strategy development and implementation. *Industrial Marketing Management*, *30*(6), 525.
United States Environmental Protection Agency. (n.d.). *Textiles-Common wastes & Materials.* Retrieved 9/10/2010, 2010, from http://www.epa.gov/osw/conserve/materials/textiles.htm.
World Commission on Environment and Development. (1987). *Our common future.* Oxford, UK: Oxford University Press.
Van der Ryn, S., & Cowan, S. (1995). *Ecological design*. Washington, D.C.: Island Press.
Waite, M., & Platts, J. (2009). *Engineering sustainable textiles: A bamboo textile comparison*. Cambridge, UK: Department of Engineering, University of Cambridge.
Wallace, M. (2010). Real solution for real improvement: Sustainability and your cotton manufacturing supply chain. *American Apparel and Footwear Association Environmental Committee Meeting*, Washington, D.C.
Watson, M. (2008). *A review of literature and research on public attitudes, perceptions and behaviour relating to remanufactured, repaired and reused products*. Aylesbury, UK: Centre for Remanufacturing and Reuse.
Welters, L. (2008). The fashion of sustainability. In J. Hethorn, & C. Ulasewicz (Eds.), *Sustainable fashion, why now? a conversation about issues, practices, and possibilities* (pp. 7-29). New York, New York: Fairchild Books, inc.
White, A., & Shapiro, K. (1993). Life cycle assessment. *Environmental Science & Technology*, *27*(6), 1016-1017.
Williams, S. (2011, Make, mend and do. *Telegraph Magazine*, 38-43.
Woodruff, R. B. (1997). Customer value: The next source for competitive advantage. *Journal of the Academy of Marketing Science, 25*(2), 139. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=9707141941&site=ehost-live&scope=site
Woolridge, A. C., Ward, G. D., Phillips, P. S., Collins, M., & Gandy, S. (2006). Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin material: An UK energy saving perspective. *Resources, Conservation and Recycling*, *46*(1), 94-103. doi:DOI: 10.1016/j.resconrec.2005.06.006
Young, C., Jirousek, C., & Ashdown, S. (2004). Undesigned: A study in sustainable design of apparel using post-consumer recycled clothing. *Clothing and Textiles Research Journal*, *22*(1-2), 61-68.

APPENDICES

Appendix A: Survey Materials

Appendix A1: Invitation Letter

North Carolina State University is a land-Grant university and a constituent institution of The University of North Carolina

Department of Textile and Apparel Technology and Management
www.tx.ncsu.edu/tam/

NC STATE UNIVERSITY

College of Textiles
2401 Research Drive
Raleigh, NC 27695-8301

919.515.3442 (telephone)
919.515.3733 (fax)

2/3/2011

Mallory McConnell
North Carolina State University
Textile and Apparel Technology Management

Dear Sir/Madam,

The College of Textiles at NC State University is conducting research to study indicators associated with sustainable products. Your participation in this study is voluntary and any data that you provide will be held in the strictest confidence where the identity of yourself or your company will not be associated with any data elements in my Master's Thesis or subsequent presentation or publications.

The goal of this research is to determine sustainability indicators which may form the basis of textile and apparel products and firms being promoted and marketed as sustainable. You are being contacted because of your standing in the field of sustainability and the survey should take approximately 15 minutes of your time. Your input will help prioritize sustainable indicators in order to define a practical approach for sustainable development.

To participate in this study, please click on the linked survey.

https://www.surveymonkey.com/s/SustainabilityInsights

Your cooperation is greatly appreciated. If you have any questions concerning this study, please contact me at mmmcconn@ncsu.edu

Sincerely,

Mallory McConnell

Graduate Student
North Carolina State University
MS Textiles program, Textile and Apparel Technology and Management

Dr. Trevor Little
Professor
North Carolina State University
College of Textiles
Trevor_Little@ncsu.edu

Appendix A2: Reminder Letter

North Carolina State University is a land-Grant university and a constituent institution of The University of North Carolina

Department of Textile and Apparel Technology and Management
www.tx.ncsu.edu/tam/

NC STATE UNIVERSITY

College of Textiles
2401 Research Drive
Raleigh, NC 27695-8301

919.515.3442 (telephone)
919.515.3733 (fax)

2/18/2011

Mallory McConnell
North Carolina State University
Textile and Apparel Technology Management

Dear Sir/Madam,

This is a friendly reminder to please complete the survey for the College of Textiles at NC State University if you wish to participate as the survey will be closing soon.

To participate in this study, please click on the linked survey.

https://www.surveymonkey.com/s/SustainabilityInsights

Your cooperation is greatly appreciated. If you have any questions concerning this study, please contact me at mmmcconn@ncsu.edu

Sincerely,

Mallory McConnell

Graduate Student
North Carolina State University
MS Textiles program, Textile and Apparel Technology and Management

Dr. Trevor Little, Ph. D.
Professor—NCSU

Trevor_Little@ncsu.edu

Appendix A3: Survey Documents

1. Consent

* 1. North Carolina State University
INFORMED CONSENT FORM for RESEARCH
Title of Study: Sustainability Insights

Principal Investigator: Mallory McConnell Faculty Sponsor: Dr. Trevor Little

You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time.

The purpose of this study is to provide a greater understanding of sustainability indicators which form the basis of a product or firm to be labeled and promoted as sustainable. The survey results will become part of the published master's research conducted by Mallory McConnell (mmmcconn@ncsu.edu). If you agree to participate in this study, you will be asked to complete the following questions.

The information in the study records will be kept strictly confidential. Data will be stored securely on a password protected server accessible only by the principal investigators. SLL encryption will be used for transmitting survey results. No reference will be made in oral or written reports which could link you or your company to the study.
There is no monetary compensation. You will not receive anything for participating in this study other than the knowledge that you are contributing to building a greater body of work about sustainability. There are no foreseeable risks associated with completing this survey or participating in the case study.

If you have questions at any time about the study or the procedures, you may contact the researcher, Mallory McConnell, at mmmcconn@ncsu.edu or (919) 515-6633. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Arnold Bell, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7514, NCSU Campus (919/515-4420).

By checking the “I accept” box I acknowledge I have read and understand the above information and am over the age of 18. I may print a copy of this agreement for my

Page 1

records. I agree to participate in this study with the understanding that I may withdraw at any time.

- I accept
- I do not accept

2. Company overview

To gain information on existing products and practices

*** 1. Does your company currently have a Corporate Social Responsibility statement?**

- Yes
- No

*** 2. Is your company's Corporate Social Responsibility policy available to the public for review?**

- Yes
- No

*** 3. Does your company currently have an Environmental Health and Safety policy?**

- Yes
- No

*** 4. Is your company's Environmental Health and Safety policy available to the public for review?**

- Yes
- No

*** 5. Does your company currently produce, design, or retail a product marketed as sustainable, green, eco-friendly, or environmentally friendly?**

- Yes
- No

6. **If yes, please describe the product and characteristics which make it sustainable (mark all that apply)**

- [ ] Organic
- [ ] Recyclable
- [ ] Reusable
- [ ] Made from recycled material
- [ ] Fair trade
- [ ] Energy efficient
- [ ] Water efficient
- [ ] Low/Non polluting

Other (please specify)

* **7. Does your company currently have or currently working on any third party certifications?**

- ( ) Yes
- ( ) No

8. If so, please list the third party certifications/certification bodies

3. End of life page 1

* 1. How much experience do you have working with product end-of-life options (i.e. recycling, reuse, re-purposing)?

- Less than one year
- One to three years
- Three to five years
- Five or more years

4. end of life page 2

1. Please list 2-3 social issues of concern related to product end of life

2. Please list 2-3 economic issues of concern related to product end-of-life

3. Please list 2-3 environmental issues of concern related to product end of life

5. end of life page 3

*** 1. On a scale of 1-7, rate the following end of life indicators in terms of overall importance**

	Not Important			Important			Very Important
Product is designed to be reused, refilled, or re-purposed							
Company has an end-of-life management system							
Product is designed to minimize variety of materials							
Company offers a take-back service							
Material components are identifiable							
Product is easily disassembled							
Product is designed to avoid blending materials							
Product is designed to be recycled							
Company supports a third party organization for product take-back services							

*** 2. Of the available indicators, please indicate the top three most important end of life indicators from the pull down menu in order from most important, 2nd most important and third most imporant**

	Most Important	2nd Most Important	3rd Most Important
Product End-of-Life			

6. End of life page 4

*** 1. On a scale of 1-7, please rate the following end of life indicators on ease of implementation**

	Easy to implement		Moderately easy to implement		Moderately difficult to implement		Difficult to implement
Company supports a third party organization for product take-back services	◯	◯	◯	◯	◯	◯	◯
Product is designed to minimize variety of materials	◯	◯	◯	◯	◯	◯	◯
Product is designed to be recycled	◯	◯	◯	◯	◯	◯	◯
Product is easily disassembled	◯	◯	◯	◯	◯	◯	◯
Product is designed to be reused, refilled, or re-purposed	◯	◯	◯	◯	◯	◯	◯
Company offers a take-back service	◯	◯	◯	◯	◯	◯	◯
Product is designed to avoid blending materials	◯	◯	◯	◯	◯	◯	◯
Material components are identifiable	◯	◯	◯	◯	◯	◯	◯
Company has an end-of-life management system	◯	◯	◯	◯	◯	◯	◯

7. Processing and manufacturing page 1

*** 1. How long have you been working in the area of processing and manufacturing**

- Less than one year
- One to three years
- Three to five years
- More than five years

8. Processing and manufacturing page 2

1. Please list 2-3 social issues of concern relating to processing and manufacturing

2. Please list 2-3 economic issues of concern related to processing and manufacturing

3. Please list 2-3 environmental issues of concern related to processing and manufacturing

9. Processing and manufacturing page 3

*1. On a scale of 1-7, rate the following processing and manufacturing indicators in terms of overall importance

	Not Important			Important			Very Important
Company has a plan to minimize number of production methods and operations							
Company has developed an environmental management system at facility							
Company has a plan to reduce water use at facility							
Company measures quality of air emissions at facility							
Company measures hazardous waste generated at facility							
Company measures water use at facility							
Company has a plan to reduce solid waste at facility							
Company measures quantity and quality of wastewater discharged at facility							
Company has a plan to reduce energy use at facility							
Company measures solid waste at facility							
Company measures energy use at facility							

*2. Of the provided indicators, please choose the three most important processing and manufacturing indicators from the pull down menu in order of overall importance from most important, second most important, and third most important

	Most Important	2nd Most Important	3rd Most Important
Processing and manufacturing			

10. Production and manufacturing page 4

*** 1. On a scale of 1-7, please rate the following processing and manufacturing indicators in terms of ease of implementation**

	Easy to implement		Moderately easy to implement		Moderately difficult to implement		Difficult to implement
Company has developed an environmental management system at facility	◯	◯	◯	◯	◯	◯	◯
Company measures energy use at facility	◯	◯	◯	◯	◯	◯	◯
Company has a plan to reduce solid waste at facility	◯	◯	◯	◯	◯	◯	◯
Company measures solid waste at facility	◯	◯	◯	◯	◯	◯	◯
Company measures water use at facility	◯	◯	◯	◯	◯	◯	◯
Company measures hazardous waste generated at facility	◯	◯	◯	◯	◯	◯	◯
Company measures quality of air emissions at facility	◯	◯	◯	◯	◯	◯	◯
Company measures quantity and quality of wastewater discharged at facility	◯	◯	◯	◯	◯	◯	◯
Company has a plan to reduce water use at facility	◯	◯	◯	◯	◯	◯	◯
Company has a plan to minimize number of production methods and operations	◯	◯	◯	◯	◯	◯	◯
Company has a plan to reduce energy use at facility	◯	◯	◯	◯	◯	◯	◯

11. Packaging and Distribution page 1

*** 1. How long have you been working with packaging and distribution of textile and apparel products?**

- Less than one year
- One to three years
- Three to five years
- Five or more years

12. Packaging and Distribution page 2

1. Please list 2-3 social issues of concern related to product packaging and distribution

2. Please list 2-3 economic issues of concern related to product packaging and distribution

3. Please list 2-3 environmental issues of concern related to product packaging and distibution

13. Packaging and Distribution page 3

*** 1. On a scale of 1-7, rate the following packaging and distribution indicators in terms of overall importance**

	Not Important			Important			Most Important
Post-Consumer recycled content is used in packaging							
Company uses efficient transport system							
Packaging is designed to be recycled							
Packaging is sourced from certified and traceable sources							
Packaging and product weight are minimized							
Packaging is designed to be reused							
Company has a Packaging Restricted Substance List (PRSL)							
Packaging material is minimized							

*** 2. Of the provided indicators, please give the top three most important packaging and distribution indicators from the pull down menu in terms of most important, second most important, and third most important**

	Most Important	2nd Most Important	3rd Most Important
Packaging and Distribution			

14. Packaging and Distribution page 4

*** 1. On a scale of 1-7, please rate the following packaging and distribution indicators in terms of ease of implementation**

	Easy to implement		Moderately easy to implement		Moderately difficult to implement		Difficult to implement
Packaging is designed to be reused	◌	◌	◌	◌	◌	◌	◌
Packaging and product weight are minimized	◌	◌	◌	◌	◌	◌	◌
Packaging is sourced from certified and traceable sources	◌	◌	◌	◌	◌	◌	◌
Company has a Packaging Restricted Substance List (PRSL)	◌	◌	◌	◌	◌	◌	◌
Packaging is designed to be recycled	◌	◌	◌	◌	◌	◌	◌
Post-Consumer recycled content is used in packaging	◌	◌	◌	◌	◌	◌	◌
Company uses efficient transport system	◌	◌	◌	◌	◌	◌	◌
Packaging material is minimized	◌	◌	◌	◌	◌	◌	◌

2. Has your company developed or adopted a Packaging Restricted Substances List (PRSL)?

◌ Yes

◌ No

3. If so, is the Packaging Restricted Substances List available to the public for review?

◌ Yes

◌ No

15. Materials page 1

Rating of material indicators

*** 1. How long have you been working in the materials area?**

- Less than one year
- One to three years
- Three to five years
- More than five years

16. Materials page 2

1. Please list 2-3 social issues of concern relating to materials

2. Please list 2-3 economic issues of concern relating to materials

3. Please list 2-3 environmental issues of concern relating to materials

17. Materials page 3

* 1. On a scale of 1-7, rate the following material indicators in terms of overall importance

	Not Important			Important			Very Important
Sourcing materials from renewable sources							
Using materials which require less energy to cultivate							
Using materials which require less water to cultivate							
Utilizing post-consumer recycled materials							
Making Restricted Substance List available to public							
Utilizing pre-consumer recycled materials							
Souring materials locally							
Using materials which create less waste							
Using materials which create less environmental impacts							
Using materials which can be recycled back into production as inputs							
Identifying and eliminating chemicals of concern							
Efficient use of raw materials							
Using materials which will degrade back into the environment less than 5 years after use							
Using natural fibers							
Avoiding toxic materials							
Creating a Restricted Substance List (RSL)							
Using certified organic fibers							

* 2. Please select the top three most important material indicators from the pull down menu in terms of most important, second most important, and third most important

	Most Important	2nd Most Important	3rd Most Important
Material Indicators			

18. Materials page 4

*** 1. On a scale of 1-7, please rate the following material indicators in terms of ease of implementation**

	Easy to implement		Moderately easy to implement		Moderately difficult to implement		Difficult to implement
Using materials which will degrade back into the environment in less than 5 years after use							
Using materials which require less water to cultivate							
Using materials which require less energy to cultivate							
Using certified organic fibers							
Creating a Restricted Substance List (RSL)							
Using natural fibers							
Sourcing materials from renewable sources							
Making Restricted Substance List available to public							
Identifying and eliminating chemicals of concern							
Souring materials locally							
Utilizing post-consumer recycled materials							
Using materials which can be recycled back into production as inputs							
Using materials which create less environmental impacts							
Utilizing pre-consumer recycled materials							
Efficient use of raw materials							
Using materials which create less waste							
Avoiding toxic materials							

*** 2. Has your company developed or adopted a Restricted Substances List (RSL)?**

- Yes
- No

3. If your company has developed or adopted a Restricted Substance List (RSL), is it made available to the public for review?

- Yes
- No

19. Aftercare and Use page 1

*** 1. How long have you been working in the area of aftercare and use?**

- Less than one year
- One to three years
- Three to five years
- More than five years

20. Aftercare and Use page 2

1. Please list 2-3 social issues concerning aftercare and use

2. Please list 2-3 economic issues concerning aftercare and use

3. Please list 2-3 environmental issues concerning aftercare and use

21. Aftercare and Use page 3

* 1. On a scale of 1-7, rate the following aftercare and use indicators in terms of overall importance

	Not Important			Important			Very Important
Company offers product upgrades							
Product is designed for durability and longevity							
Product is designed for low impact care and laundering							
Company offers repair/refurbishment services							
Product has a warranty							
End-of-life options are communicated to consumers							
High quality materials are used							

* 2. Please choose the three most important aftercare and use indicators from the pull down menu in order from most important, second most important, and third most important

	Most Important	2nd Most Important	3rd Most Important
Use and Aftercare			

22. Aftercare and Use page 4

*** 1. On a scale of 1-7, please rate the following aftercare and use indicators in terms of ease of implementation**

	Easy to implement		Moderately easy to implement		Moderately difficult to implement		Difficult to implement
Product is designed for durability and longevity	○	○	○	○	○	○	○
Company offers product upgrades	○	○	○	○	○	○	○
Product has a warranty	○	○	○	○	○	○	○
Company offers repair/refurbishment services	○	○	○	○	○	○	○
High quality materials are used	○	○	○	○	○	○	○
End-of-life options are communicated to consumers	○	○	○	○	○	○	○
Product is designed for low impact care and laundering	○	○	○	○	○	○	○

23. Social Dimension

To capture importance of social indicators

*** 1. How long have you been working in the area of social responsibility?**

- Less than one year
- One to three years
- Three to five years
- More than five years

24. Social dimension page 2

1. Please list 2-3 economic issues of concern relating to social responsibility for your company

2. Please list 2-3 environmental issues of concern relating to social responsibility for your company

25. Social dimension page 3

*** 1. On a scale of 1-7, rate the following social indicators in terms of overall importance**

	Not Important			Important			Very Important
Third party certification for social responsibility							
Company has developed an infrastructure and provides services for the public benefit							
Company has developed a corporate ethics/fair labor statement and made it publicly available							
Employment is freely chosen							
Workers are trained							
Some senior management is hired from the local community							
No use of child labor							
Employees are paid living wages							
Employees have freedom of association and collective bargaining							

*** 2. Please choose the top three most important social indicators from the pull down menu in terms of most important, second most important, and third most important**

	Most Important	2nd Most Important	3rd Most Important
Social Indicators			

3. Please indicate any other social issues or concerns which may have been left out of the above list

26. Social dimension page 4

*** 1. On a scale of 1-7, rate the following social indicators in terms of ease of implementation**

	Easy to implement		Moderately easy to implement		Moderately difficult to implement		Difficult to implement
Employees are paid living wages							
Some senior management is hired from the local community							
Company has developed an infrastructure and provides services for the public benefit							
Employees have freedom of association and collective bargaining							
Third party certification for social responsibility							
No use of child labor							
Company has developed a corporate ethics/fair labor statement and made it publicly available							
Employment is freely chosen							
Workers are trained							

27. Company activities

* 1. Please indicate your company's types of operations (Please mark all that apply)

- [ ] Fiber production
- [ ] Yarn production
- [ ] Dyeing and/or finishing
- [ ] Knitting
- [ ] Weaving
- [ ] Non-Wovens
- [ ] Cut and Assembly
- [ ] Academic
- [ ] Distribution
- [ ] Retail

Other (please specify)

28. The End

Thank you so much for taking this survey. Your insights are greatly appreciated