Sustainability in the Product Cycle: Adopting a Shared Standard for the Apparel Industry
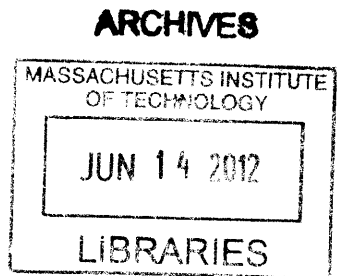
by

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Sustainability in the Product Cycle: Adopting a Shared Standard for the Apparel Industry

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Abstract

Decisions made by product designers strongly influence the social and environmental impacts that a consumer product will have over its lifetime. This study examines the Sustainable Apparel Index, a decision-support tool that aims to clarify environmental trade-offs and reduce overall product impacts within the apparel industry. As an example of the broad potential for shared industry standards, the Apparel Index is compared to other, company-specific apparel tools, which exist to integrate environmental knowledge into the product creation process. Based on this comparative analysis as well as primary research within the industry, the thesis draws the following conclusions:

1) There are ways to make tools more user-friendly for designers, by paying attention to collaboration types and decision-making systems.
2) It is important to maintain existing workflow; embedding intelligence into tools and processes can help.
3) Efforts to share resources should focus on certain elements of knowledge and decision-making systems, where sharing will add the most value.
4) There is a key trade-off between speed and transparency, so shared tools should allow for flexibility according to user preferences.

The study concludes with three recommendations for ways to improve the Sustainable Apparel Index, increasing its utility for product designers. In addition to suggesting improvements to future versions of the Apparel Index, the findings described here are relevant to other consumer goods industries such as electronics, toys, and furniture, which feature supply chains of a similar global scope.

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Acknowledgments

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1. Introduction

1.1. Project Overview

In industrialized countries, consumer goods drive an enormous amount of economic activity: in 2010 US spending on consumer goods totaled $13.5 trillion (BEA 2012). Globally, all this shopping ties American lifestyles to developing economies, and to the impacts of producing goods and shipping them around the world. Amid the competition for growth, environmental impacts are often accepted as the inevitable cost of living.

In a small but growing number of industries, however, shared standards are becoming powerful vehicles for improving sustainability. Over the last two decades, such standards have emerged in forestry (FSC), fisheries (MSC), and the building industry (LEED). Individual companies can set better internal targets and policies when they share an awareness of potential social and environmental impacts in all stages of the value chain, as well as common definitions, metrics, and evaluation protocols. However there are also many potential barriers to achieving industry-wide cooperation, including governance and privacy issues across firms, decision-making practices within firms, data availability and quality, and supplier transparency, power, and participation.

There are many existing lenses for looking at how multiple stakeholders (including companies, NGOs, and government) collaborate to adopt shared standards for sustainability across an industry. Instead of examining interactions across organizations, this study focuses on *internal*, company-level factors, especially: processes for turning data into knowledge, systems for making decisions, and the structure of tools designed to

aid decision-making. Its primary question is: *How can information about social and environmental impacts be effectively integrated into new product creation?*

Lifecycle thinking, with or without the use of formal tools of lifecycle analysis (LCA), is the commonly-accepted starting point for answering this question. This thesis considers LCA from two critical perspectives, adding to the discussion of its potential as well as its limitations for consumer goods industries. With this foundation, research interviews and analysis of public documents map the informational inputs and outputs of existing index tools, showing which elements are most resource-intensive in terms of time, money, and/or expert knowledge – and suggesting that there are natural advantages to sharing such resources. By relating patterns of knowledge to the decision-making systems that depend on them, it is possible to elaborate on the collaborative needs of design teams using a tool like the Sustainable Apparel Index. The study concludes with recommendations for an idealized designer-oriented tool.

1.2. The Product Lifecycle and the Product Design Cycle

A supply chain is often described as a linear process, starting with materials grown or extracted from the earth and ending with delivery of a finished product to the consumer. However, to fully understand the social and environmental impacts of a product, it is critical to examine its entire lifecycle, including use or service by the consumer and eventual disposal, re-use, or recycling. While industrial production processes are far too seldom "closed loop," it is helpful to think of product lifecycles in the form of a circle, since most materials and energy originate and eventually terminate in the biosphere.

In practice, the process of designing, developing, and delivering a new consumer product to the market (referred to here as "product creation") is also a circular progression. When creating new products, apparel companies (or "brands", as distinct from manufacturers) may take somewhat different approaches, but every product goes through phases of design, development, and manufacturing. Companies must address the same basic questions: What will we make? How will we make it? How will new products fit into our existing product lines? How much of each garment should we produce? What manufacturers and material suppliers will we use? Product creation involves many decision points and modes of collaboration, both within the firm and with outside parties such as material suppliers and contract manufacturers.

Figure 1. The Product Life Cycle and the Product Creation Cycle

● Product Creation Cycle
● Product Life Cycle
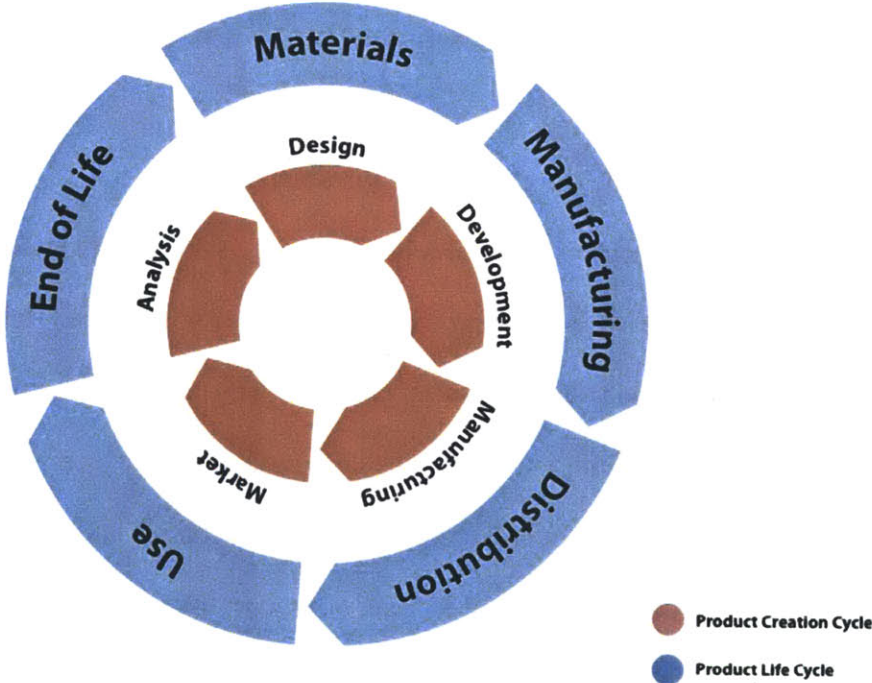
Most lifecycle-based analysis looks at the flow of energy and materials along the outer circle, but does not consider the flow of ideas and information that takes place along the inner circle. As we will see, the design cycle impacts the product lifecycle in varied and compelling ways. Others have noted that early interventions in design can minimize the environmental impacts of a product, much more painlessly than later-stage efforts. The National Research Council of Canada estimates that 70% of the costs of product development, manufacture, and use are determined during the initial design phase (Kurk and McNamara), and these decisions typically commit a product to its eventual environmental performance.

This thesis argues that by looking closely at flows of environmental information and systems for decision-making, we can better understand tools that exist to improve sustainability at the product level. The insights that result from this examination will be used to make sense of the challenges and opportunities of implementing shared sustainability standards, hopefully informing future versions of the SAI or similar initiatives in consumer goods.

1.3. Sustainability Issues in the Apparel Industry

Globally, the apparel sector is worth over $1 trillion and employs approximately 26 million people (Defra 2007). These social and economic benefits are associated with significant social and environmental costs, ranging from dangerous and unjust overseas labor practices (Henderson, Locke, Lyddy, and Reavis 2009) to the environmental footprint of cotton – which uses 25% of all insecticides and upwards of 7,000 liters of

water per kilogram (WWF 1999). A systematic sustainability assessment involves mapping out the stages in the typical apparel supply chain. There are several distinct phases of manufacturing: fabric production (natural fibers involve farming, ginning and spinning, and knitting/weaving; synthetic fibers involve fossil fuel extraction and fiber manufacturing); dyeing and finishing; cutting and sewing; and final assembly. Garments are then packaged, transported, worn and laundered by the consumer, and finally disposed of or reclaimed at the end of life.

Figure 2: Lifecycle of Natural and Synthetic Textiles
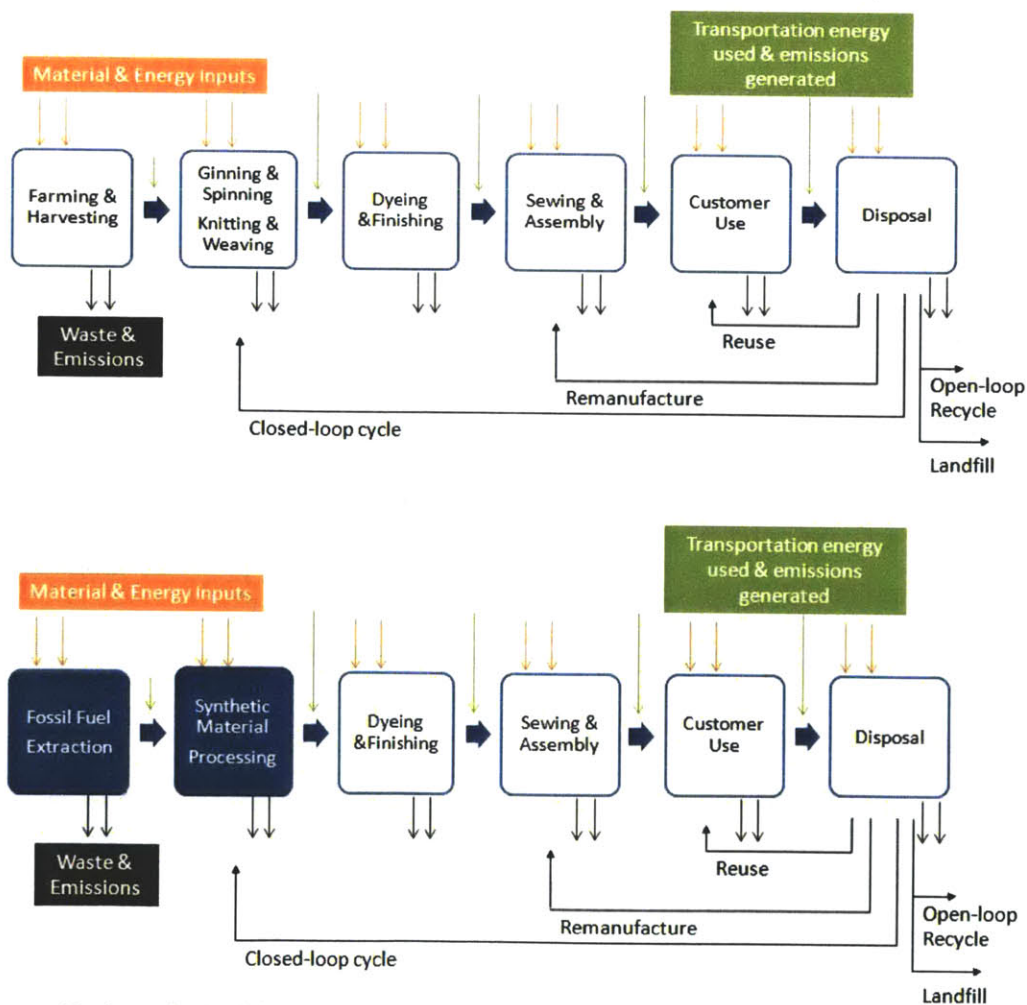
Source: Business for Social Responsibility (2009)

Apparel is a fast-moving, global industry, and efforts to improve sustainability have been fragmented. Some individual brands launched social codes of conduct in the 1990s, in reaction to negative reports on working conditions in suppliers' factories. Multilateral efforts have so far sprung up around single materials (Better Cotton Initiative, Leather Working Group), impact areas such as chemistry (bluesign standard) or industry sub-sectors (Outdoor Industry Association's Environmental Working Group). On the research side, the LCA community has developed methods and studies specifically focusing on textiles (Dahllof 2003; Steinberger, Friot, Jolliet, and Erkman 2009).

1.3.1. The Sustainable Apparel Coalition

The Sustainable Apparel Coalition (SAC) is a multi-stakeholder association focused on increasing sustainability in the apparel and footwear industry. Members of the SAC began working together informally in 2010; many have been members of the Outdoor Industry Association's Environmental Working Group for years.[1] The SAC's Founding Circle includes industry members representing approximately 30% of global retail sales, as well as representatives from NGO, academic, and government sectors (Whalen 2011). Industry members represent four major stages of the apparel supply chain: raw materials, manufacturers, brands, and retailers. Currently, membership in the Coalition is by invitation only; the Coalition continues to develop both its internal governance structures/processes and the Sustainable Apparel Index.

The SAC's founding purpose is to address the industry's current social and environmental challenges, both as a business imperative and as a source of opportunity.

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[1] SAC was incubated by Blu Skye, a San Francisco-based strategy consulting firm.

The hypothesis supporting the formation of the SAC is that the significant issues in the industry are systemic, and therefore cannot be addressed without collaboration and collective action. Furthermore, pre-competitive collaboration can both accelerate improvement in social and environmental performance and lower the cost for individual companies (Whalen 2011).[2] If successful, such collaboration allows participants to direct more resources toward product and process innovation, rather than toward defining standards. While the various stakeholders across the industry have a range of competitive interests, they nonetheless share a common interest in having "credible, practical, and universal" tools and standards for sustainability (Whalen 2011).

1.3.2. The Sustainable Apparel Index

Members of the SAC have defined a "vision of sustainability built upon a common approach for measuring and evaluating apparel and footwear product sustainability performance that will spotlight priorities for action and opportunities for technological innovation" (Sustainable Apparel Coalition 2011). In 2011, the SAC launched the Sustainable Apparel Index (SAI), aiming to create an industry-standard approach for measuring impacts and improving decision-making. Initially, the SAI Version 1.0 has been a pilot test for member companies, intended to serve as a business-to-business tool only. However, Coalition members acknowledge and expect that consumer-facing scoring will most likely exist in the future, and that such a score or label may be based on the framework of the SAI. Version 1.0 is the first of a multi-phase rollout, as follows:

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[2] As a pre-competitive forum, the SAC must ensure that its members avoid collusive behavior that could lead to antitrust violations. For example, discussion of pricing, collaborative sourcing, or marketing plans in such a forum could represent such a violation.

Version 1.0: Excel-based tool focused on apparel only. The tool is based on indicators of environmental performance; many questions are therefore answered yes/no or with qualitative responses, and documentation of claims is not required. The first release of the SAI includes only environmental indicators, with plans to add indicators for social criteria. While the SAI is freely available at to the public as an Excel-based document, members agree not to publicize their scores while the tool is still under development. The initial comment period closed on January 31st, 2012.

Version 2.0: In addition to basic indicators, Version 2.0 will add metrics for quantifying environmental and social performance. Such metrics will cover all phases of the product lifecycle and will measure actual outcomes, rather than practices.

Figure 3. Navigation of the Sustainable Apparel Index v1.0
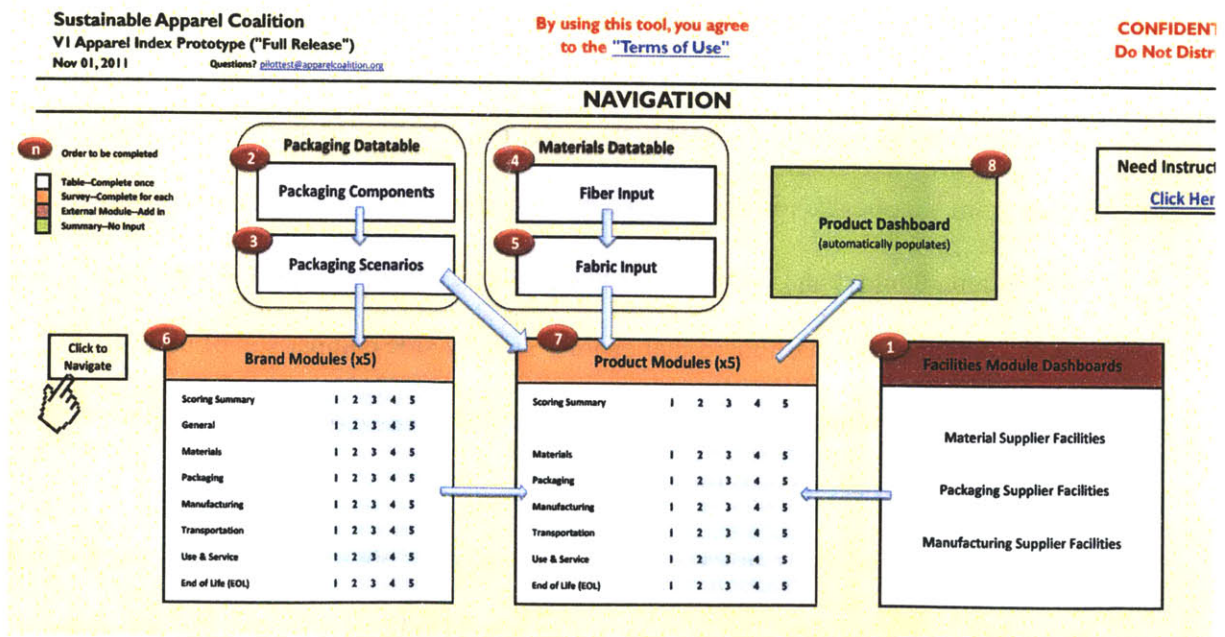
Source: SAC_V1 Apparel Index Prototype (2011).

The structure and methodology of the SAI are directly evolved from the Outdoor Industry Association's Eco Index (see Appendix). It is designed to be approachable by companies

at different levels of environmental sophistication, allowing the inexperienced to first

engage at the level of indicators, then calculate metrics as capabilities become more

advanced. The indicators that make up the SAI v1.0 address seven major impact areas[3]

throughout the entire, six-phase product lifecycle.[4] Significantly, it also imports the Nike

Materials Analysis Tool (MAT) database for scoring fibers, one of the base-level inputs

to the tool.[5]

Users interact with the SAI by inputting data, making product-related decisions, and

interpreting results through a Product Comparison Dashboard. The Index is structured

around three "modules": Brand, Facilities, and Product. The three modules are dependent

on one another; for example, the Product Module automatically draws in data on

facilities-level manufacturing practices.

Information flows through the tool in the order described in Figure 3. At the "base" level

is data from supplier facilities (obtained through a separate, 21-part questionnaire),

information about typical packaging, and a master list of fiber scores. At the "top" level,

scores are output to a dashboard that enables side-by-side comparison of up to five

products. Each product gets a summary score, combining Brand and Product sub-scores

derived from impacts in each lifecycle stage.

In Version 1.0, the SAI is an Excel workbook, and does not require any specific software

beyond Microsoft Office. The intent is for its results to be used by product designers,

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[3] Energy use and GHG emissions, water use, wastewater/effluent, emissions to air, waste management, pollution prevention, and environmental management program.
[4] Materials, packaging, manufacturing, transportation, use & service, end of life.
[5] Currently undergoing technical review by SAC.

technical development teams, material suppliers, manufacturers, and retail buyers (Whalen 2011).

1.4. Research Methods

The Sustainable Apparel Index serves as a live example of a sustainability standard for consumer goods. Examining a tool in version 1.0 presents some limitations to data collection, and the research intent is not to prematurely critique a work-in-progress. Rather, the approach taken here is to investigate the value added and potential pitfalls of the Index, especially when considered from the perspective of product design teams.

Research methods consisted of primary interviews and secondary research on sustainability tools for consumer products. Interviews were conducted with 1) senior level managers at five apparel brands, whose roles involved product design and/or product sustainability; 2) three representatives from the Sustainable Apparel Coalition and Sustainable Packaging Coalition; and 3) four industry experts in lifecycle analysis and Design for Environment (DFE) strategies. Representatives from the apparel brands participated in a structured interview, while other interviews were tailored to the participant.[6] Secondary research involved collecting and analyzing examples of sustainability standards used in the apparel and packaging industries. As some of the tools are proprietary, review of publicly-available documents was supplemented where possible with interviews inside the company.

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[6] To protect confidentiality and proprietary interests, all responses from industry participants are presented anonymously.

1.5. Foundations & Theory

To set up an examination of sustainability standards for apparel, and specifically of the SAI, we will build on theories of organizational design and collective action. This discussion begins with a review of lifecycle analysis as a specific approach to sharing product-related environmental information. It then considers different types of decision-making and the knowledge patterns that support them, driving toward a more subtle portrayal of how data becomes knowledge within an organization. Finally, this section puts the SAI into context as an artifact used by a "club" to share information and mediate a public goods problem. Along the way, we will find recurring tensions between 1) expert and non-expert approaches and 2) transparent and opaque decisions. Upcoming sections will use these sharpened perspectives to analyze examples of apparel industry tools, setting the stage for our desired outcome: a designer-friendly, shared standard.

1.5.1. Lifecycle Analysis (LCA)

Since the mid-1990s, Lifecycle Analysis (also known as Lifecycle Assessment) has emerged as a structured methodology for understanding the environmental impacts associated with manufactured products. LCA refers not to a single technique or software tool, but rather to an approach that acknowledges that environmental trade-offs exist among different types of impact;[7] without considering the product lifecycle in its entirety, it is possible to misjudge the relative influence of any single intervention. Since

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[7] For example, a styrofoam coffee cup creates more waste than a reusable mug, but consumes less water because it does not require dishwashing.

individual companies and whole industries, including apparel, are increasingly adopting this evaluation framework, LCA is briefly reviewed here.

According to the United Nations Environment Programme (1996), an LCA study follows a three-step process involving practitioner judgment and expertise:

1) Define goal and scope. In addition to defining the central question to be answered by the study, the practitioner determines the *functional unit* to be examined. For example, to compare the impacts of paper towels vs. hand dryers, an appropriate functional unit would be "hand drying"; this allows equivalent comparisons on a per-use basis. As in this case, the appropriate functional unit may be a service or "event," rather than a physical product.

2) Inventory Analysis. This is the most data-intensive step in an LCA. First, the practitioner maps out a *process flow chart* showing the steps by which raw materials are transformed into a product, then delivered for consumer use and ultimately discarded or repurposed. To create the flow chart, all materials and manufacturing processes must be defined. Next, data are collected, quantifying the inputs and outputs or impacts of each process. At this stage, LCA software tools typically link to large databases maintained by government and/or industry sources. The practitioner then defines the *system boundaries*, using sensitivity analyses and professional judgment to determine appropriate cut-off points, beyond which finer detail does not materially improve the analysis. Also in this stage, the expert analyst makes decisions about allocating impacts to specific processes.[8]

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[8] For example, if a truck transported shoes and DVDs to the same store, how much of the vehicle's emissions to allocate to the shoes.

3) Impact Assessment. This stage involves interpreting the quantitative results of the analysis and associating them with impacts, typically forms of damage to environmental quality and human health. Contributions are "characterized," using conversion factors as necessary to translate different outputs into equivalent units (such as kg CO2-equivalent or Disability Adjusted Life Years). Implicit in the characterization step are models, such as how carcinogens affect DALYs, that are subject to variation and improvement over time. Models can be quite complex; for example, the impacts of water consumption vary with geography (Steinberger, Friot, Jolliet, and Erkman 2009). Typically, the final product of the LCA will be a profile of impacts across several categories. It then lies with the user to compare impacts and assign weights or priorities. This stage can lead to difficult trade-offs and questions, the answers to which are "not so much a matter of science but more of opinion" (UNEP 1996).

Conducting a full LCA is generally considered an expert exercise. In addition to a scientific community of practitioners, international associations such as ISO[9] and SETAC[10] serve to standardize methodologies for LCA. One important piece of guidance from ISO is that impacts should generally be presented at the "midpoint" level (such as climate change or eutrophication), not only as a single combined score, in order to clearly show where any weighting has been applied across impact categories (Jolliet et al. 2004).

Benefits and Limitations of LCA

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[9] International Organization for Standardization
[10] Society of Environmental Toxicology and Chemistry

An LCA study results in a comprehensive, quantitative assessment of a product's impact in one or more areas of concern.[11] The results can be used in a few different ways. A product-centric LCA provides a detailed evaluation of environmental impacts by lifecycle stage, and can be used to identify areas of greatest impact. Comparing quantitative results to a baseline can show changes in performance over time, or relative impacts of similar products. A user can run the LCA multiple times while changing a key variable, such as material type, to observe the impacts on final results. A full LCA can provide a solid, defensible basis for choosing one material or process over another.

There are also limitations to using LCA to aid product decision-making. One is that appropriate data sets are not always available for every material and process. In apparel, manufacturing data may only be available for the US or Europe, while factories are most often located in developing countries (Steinberger, Friot, Jolliet & Erkman 2009). Most LCA software draws on large databases that reflect industry average performance and impacts; individual companies that know their supply chains well will prefer to use primary data specific to their products and facilities. The ISO 14020 series explains, and limits, the extent to which LCA can be used for making comparisons across products.

In addition, conducting a full LCA is generally time- and resource-intensive. Product specifications must be well defined in order to input the appropriate materials, quantities, and manufacturing processes. Generally such details are only available at the end of the product development stage, meaning that a full LCA cannot be conducted with only

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[11] LCA usually includes greenhouse gas emissions at a minimum, but may also include measures of water consumption and pollution, other air pollution, environmental toxicity, solid waste, etc.

design-stage information. Some variations of LCA streamline data needs, such as the "I-O" method which uses economic inputs and outputs (e.g. measured in dollars) to approximate environmental impacts (Kaenzig, J., Friot, J.D., Saadé, M., Margni, M., and Jolliet, O. 2011). It is also very difficult to quantify social impacts in a way that allows them to be included in a rigorous LCA. Since considerations such as workplace safety and fair wages are highly relevant in the apparel industry, a tool that focuses only on environmental impacts leaves out important information.

Finally, an LCA is a snapshot in time, one that is subject to interpretation. Confidence in the outputs of the process depends on high quality data and a practitioner with enough experience to follow protocols and exercise good judgment. Like any data, inputs to an LCA study can be misused or manipulated. There is also room for disagreement among highly qualified users; while protocols for handling data may be well-defined, other parameters – such as the timeframe to use when considering CO2 emissions to the atmosphere – may be judged differently by different experts, or misunderstood completely by non-experts.

1.5.2. Boundary Objects

An LCA report is an artifact used to share data, capture knowledge, and guide action. To put such tools in a broader context, a segment of the literature on organizational processes and design exploring so-called "boundary objects" is useful here. Specifically,

this literature is rich in theory about how knowledge informs decision-making, a central theme of this thesis.

Lawrence and Lorsch's classic theory of organizational effectiveness (1967) calls attention to the patterns of knowledge found within an organization, emphasizing the impacts of structural characteristics. It is first important to distinguish between differences in degrees of knowledge, such as exist between a master chef and a novice prep cook, versus differences in types of knowledge, for example between a biology professor and a licensed engineer. Building on the conclusion that complex organizations must effectively *differentiate* or create depth in specialized knowledge, while also *integrating* or unifying efforts across specializations, Thompson (1967) describes three types of interaction within organizations. In *pooled* systems, actors can work more or less independently as long as they share certain protocols, as when software programmers use a common coding language. In *sequential* systems, work must be completed or decisions made by one actor before the next task can be performed. Finally, in *reciprocal* systems, individual parties possess only partial knowledge or capabilities, and must interact in real time in order to complete a shared task. (Note that "organization" is used somewhat loosely, referring to any group of people working together toward a shared purpose).

From this sketch of collaboration types and related dependencies, we can start to watch for certain natural patterns of interaction in the product development cycle. We should also expect different forms of collaboration to have different organizational success

factors. Just as asynchronous workflows are better suited to some interactions than others, it makes sense that modes of decision-making will vary:

Type of interaction	What makes it work?
Pooled	Transparency and compliance with shared rules and protocols
Sequential	Accountability and clarity of decision points
Reciprocal	Participation and effective communication/negotiation

Any group of individuals working together needs to exchange information, whether in the form of raw data or well-refined knowledge. Carlile (2002, 2004) provides a foundation for understanding these exchanges by describing three types of knowledge "boundaries" that must be bridged for effective collaboration. *Syntactic* boundaries, a term with roots in the shared syntax of software code, are gaps in information expressed within a shared language. Crossing such a boundary therefore requires a simple transfer of information from one party to the other. *Semantic* boundaries are differences in language and/or meaning; the same situation or information may suggest different interpretations to different parties. Some degree of translation is necessary in order to work across this type of boundary. Finally, *pragmatic* boundaries involve knowledge differences that cannot be resolved by simple translation. Instead, parties at this type of boundary have divergent interests, and must negotiate these differences in order to make decisions. In other words, pragmatic boundaries are political in nature.

In this context, a "boundary object" is something that helps facilitate the crossing of knowledge boundaries. It may be an artifact such as a specifications document or a

practice such as a weekly coordination meeting. Understanding what types of boundaries exist in different situations, people can more intelligently build the bridges necessary to span across them.[12]

For example, Carlile (2004) describes the coordination challenges at an auto manufacturer, among several groups involved in product design. One party, the vehicle styling group, was used to representing its concepts with 3-dimensional clay models; other parties responsible for engineering needed to convey a fine degree of information through drawings, calculations, and specifications. Clay models were an insufficient medium for conveying such information, but tended to dominate the design process nonetheless, since "the consequences of downstream knowledge generally have a harder time being represented earlier in the process, putting upstream knowledge (i.e. designing a product or policy) in a politically stronger position" (Carlile 2004, p. 565). To improve their design process, the company developed a simulation tool that used Computational Fluid Dynamics (CFD) to create 3D representations of design concepts, putting alternatives and consequences into a format that all parties could understand and interact with. Table 1 summarizes the three types of knowledge boundary and characteristics of typical objects used to mediate them:

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[12] For a discussion of how boundary *organizations* can also mediate collaborative interactions, see O'Mahony and Bechky (2008).

Table 1: Type of Knowledge Boundary, Category, and Characteristics
of Boundary Objects

Type of Knowledge Boundary	Categories of Boundary Objects	Characteristics of Boundary Objects
Syntactic	Repositories	Representing
Semantic	Standardized Forms and Methods	Representing and Learning
Pragmatic	Objects, Models, and Maps	Representing, Learning, and Transforming

Source: Carlile (2002, p. 453)

Stepping back from product design and development, most organizations of any complexity "learn" by integrating and/or creating knowledge. In order to understand how patterns of knowledge affect systems of decision-making, it is helpful to look at organizational learning as an iterative process of acquiring, storing, and retrieving knowledge. Carlile and Rebentisch call this the "knowledge transformation cycle," setting the stage for examining the inputs and outputs at each phase (Carlile and Rebentisch 2003). Rather than dwelling on the structure of this cycle, however, they emphasize that knowledge transformation is a process continually created and re-created by its participants. For example, it takes some degree of judgment or expertise to know whether knowledge "stored" in a shared system can be "reused" in novel situations. A boundary object therefore is not a material intervention; even a very simple object can be effective if embedded in the right norms and processes.[13]

The theoretical frame of boundary objects/organizations offers some guidance in analyzing tools, such as the Sustainable Apparel Index, that are designed to be integrated

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[13] For example, in the Toyota Production System operating procedures were not explicitly codified, but rather taught to each participant by a master operator (Spear and Bowen 1999).

with a creative process. With a keen eye for information flows, types of knowledge boundaries, and instruments for crossing them, we further refine our perspective on tools for sustainable design. Which steps require expert-level knowledge or skills? What elements can be used effectively by non-experts who have different types or degrees of knowledge? If we look closely at the product design cycle, what decision types typically dominate each stage, and what does that teach us about designing appropriate tools?

1.5.3. Club Goods and Certifications

A final perspective on environmental knowledge, expertise, and decision-making is provided by a discussion of "club goods." The Sustainable Apparel Coalition can be considered a type of club, defined as a voluntary association formed to pursue shared interests or objectives. In the language of institutions, clubs "provide members with a shared group benefit, from which non-members can be excluded" (Prakash and Potoski 2006, p. 2). The literature on collective action offers a classification scheme for shared resources: private goods are excludable and rival (meaning that as the good is "consumed" by one party, it is no longer available to another); public goods are non-excludable and non-rival; common-pool resources are non-excludable and rival. In the fourth quadrant of this scheme, excludable but non-rival, public institutions often fall short of managing the resource.[14] This is where clubs can be especially relevant.

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[14] Apparel companies typically have global supply chains, major parts of which operate in countries where social and environmental regulations can be ineffective. Even in places with functioning regulatory systems, some impacts – such as factories producing large amounts of non-hazardous waste – may fall outside the scope of public regulation while also being poorly controlled by market mechanisms.

Prakash and Potoski (2006) describe two collective action problems that "green clubs" must overcome: getting members to pay the price of admission and preventing members from shirking the club's standards after they've joined. They further categorize green clubs into four types: Mandarins, Country Clubs, Boot Camps, and Greenwashes. The two defining dimensions of this classification are the level of entry barriers to joining the club (high or low) and level of enforcement (strong or weak) once an organization has gained admission. According to this scheme, the SAC in its current state would be considered a "country club": membership is by invitation only, and while organizations commit to shared leadership principles, there is not yet a formal set of enforceable criteria for maintaining membership in the club. However, it is possible for a club to change over time. Over the next 1-2 years the SAC plans to open membership to all and to formalize the metrics used in the Sustainable Apparel Index, both of which would make the SAC more closely resemble a "boot camp."

For firms, an important benefit of green club membership is sharing the costs of investments in environmental quality; for members of the SAC, this could mean sharing development costs for apparel-specific LCA methodologies, or commissioning a set of representative analyses to determine typical "hot spots" in the product lifecycle. In addition, firms that have joined a club share the intangible benefits of reputation and goodwill, as long as the club remains credible. For example, the Forest Stewardship Council and the Rainforest Alliance have created widely recognized certifications in wood/paper and food products, respectively, that confer the benefits of consumer trust and confidence on qualifying products. Notably, such certifications can be further

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legitimized when accepted into other certification schemes, as the LEED system for green buildings did by making FSC certification part of its rating scheme.

As a voluntary program, a green club maintains its standards not through public regulation but rather by self-regulation and enforcement.[15] To maintain credibility, such programs need a mechanism for verifying the practices of their members. Writing on the sociology of auditing, including environmental auditing, Power (1997) asserts that "as the state has become increasingly and explicitly committed to an indirect supervisory role, audit and accounting practices have assumed a decisive function" (Power 1997, p. 11). He further points out that verification is typically accomplished through a combination of direct or routine checking, verification of the systemic processes underlying transactions, and trust in the expert opinions of other auditors. Similar to auditing, LCA helps users "see" into the product lifecycle and evaluate the practices of suppliers.

Audits exist to increase transparency, providing assurance that unseen practices are being carried out in ways that satisfy certain expectations. Interestingly, and perhaps paradoxically, the mechanism of assurance can itself be quite opaque: "In the...case of reliance on other specialists, audits are seen to work by the construction of networks of trust in which the knowledge of others can be more or less 'black boxed' and rendered reliable" (Power 1997, p. 88). In other words, we can expect that expert knowledge, external to the firm in question, will play a critical role in voluntary systems of self-regulation. Should we therefore anticipate finding externalized, expert knowledge and

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[15] Prakash and Potoski are optimistic about the potential of boot camps, which change behavior through strong enforcement of membership standards.

certifications taking the place of direct, intimate knowledge of practices in a firm's

supply chain? At what point do scale and distance favor third-party verification of supply

chain practices? Will certification schemes become more important for consumer-facing

standards than for B2B systems like the SAI? To better understand sustainability

standards, including the SAI, we should watch for large investments in expert knowledge

in the knowledge systems that support these tools, and notice any patterns of transparency

or opacity in decision-making.

Synthesizing the theoretical perspectives described here, we should now have a more

nuanced understanding of lifecycle-based decision-making tools, the knowledge systems

that support them, and shared approaches to collective-action challenges. More broadly,

we should be aware that user needs change as a product idea moves through the design

cycle, and take this into account when considering how best to integrate environmental

information into that process.

Table 2: Characteristics of Knowledge and Decision Systems

Knowledge Type	Expert Non-expert
Interaction Type	Pooled Sequential Reciprocal
Decision Type	Participatory - Transparent Authoritarian - Opaque
Boundary Type	Syntactic Semantic Pragmatic

2. Research Findings

In the last 10-15 years, several apparel brands have begun to address sustainability concerns by gathering data and developing evaluation methods. Some of these efforts have been in-house, company-specific initiatives; others have attempted to coordinate multiple companies and other stakeholders across the industry. The Sustainable Apparel Index can be put into context by looking at some of the apparel industry tools that have preceded it. By paying attention to the ways environmental information flows into and out of these decision tools, we can understand some critical trade-offs that the SAI will also need to resolve.

2.1. Comparison of Existing Apparel Standards

In the absence of a common methodology or performance baseline, individual companies have worked to define the salient issues and set priorities for addressing impacts such as energy and emissions, water, waste, working conditions, etc. The influence they seek to have may be directed toward their own internal stakeholders (facilities managers, product designers), external stakeholders (customers, suppliers), or both. Building on these efforts, some companies have developed tools or other specific methods to capture knowledge and guide decisions. Three examples from major brands – Nike, Levi Strauss & Company, and Timberland – are compared here, in terms of their purpose, information flows, and key design decisions.

2.1.1. Nike: Considered Index

Background and purpose. Beginning in 2002, Nike started to systematically examine the environmental footprint of selected product lines and determine which impacts to prioritize (Nike, Inc. 2009). Considered Design is a broad initiative, referring to a design philosophy, an evaluation methodology, a product-centric calculator, and a labeling system. The calculator tool component of the Considered Index is intended primarily for product designers and developers. Because its purpose is both to educate and to evaluate, the Index aims to increase utility by simplifying decision-making: "There is a great deal of information embedded behind the Tool. We wanted to make it simple to use, while also fitting easily within the already demanding workload of the intended audiences" (Nike, Inc. 2012b). Index scores are used by Nike to demonstrate progress toward internal sustainability targets, as described in its Corporate Responsibility Report.

Tool design and development. The Considered Index allows users to "build" a product score by entering a limited amount of information about materials, process waste (i.e. marker efficiency), and garment trims/finishes.[16] Based on these inputs, the output is three sub-scores (Materials, Waste, Garment Treatment) that feed into an overall product score. In Waste and Garment Treatment, it is possible to receive a negative sub-score for environmentally-damaging practices/processes. The final score is a qualitative rating of "Good", "Better", "Best", or "Needs Improvement", corresponding to quantitative scores on a 0-100 scale. The methodology behind the Index emphasizes materials, manufacturing, and end-of-life stages; packaging, transportation, and service/use are

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[16] Statements in this section are inferred from the Environmental Apparel Design Tool, the publicly-available version of Nike's internal Considered Index.

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considered out of scope, although Nike takes up these concerns elsewhere in its

Corporate Responsibility Report.

The Index user does not see the underlying data or metrics of energy, water,

waste, and toxic chemical impacts. Instead, the tool allows rapid rating of products in the

design stage, so that alternative materials and processes may be compared. The Index

draws on a large, proprietary database of materials, scored according to Nike's Materials

Analysis Tool (MAT v1.5).[17] The Index is also highly integrated with Nike's internal

systems; for example, whenever possible it retrieves product information automatically

from Nike databases (Nike, Inc. 2009). Nike has made available a free, web-based

version of its Index, called the Environmental Apparel Design Tool (EADT), the outputs

of which can be exported to Excel to facilitate sharing.

Discussion. Nike has prioritized usability by design teams, focusing on the early

stages of a product's development cycle. The tool is not transparent to the level of impact

metrics; instead of a comprehensive LCA report, the user receives action-oriented

information about a set of product choices. This suggests that Nike's tool is most useful

for working across semantic boundaries such as those found during design development,

and in pooled or reciprocal work. The tight integration with other boundary objects, such

as vendor databases, likely increases the value of Nike's investment in the Index.

Environmental expertise is deeply embedded in the tool. In particular, expert

knowledge has informed the selection of key product decisions and the database of MAT

scores, which in turn draw on analysis from Nike's Green Chemistry program and on

research compiled from public sources by Brown and Wilmanns Environmental, LLC

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[17] The MAT v1.5 generates a 0-100 score based on 21 metrics of energy intensity, chemistry, waste, and water intensity; materials scores account for 60% of the overall Index score. MAT v2.0 is currently under development.

(Nike, Inc. 2012a). Scoring reveals Nike's professional judgment about environmental tradeoffs, which has evolved over time: "when we started to assess materials more than 10 years ago, chemistry issues were the driver, so we weighted it most heavily (40%) than Water/land (16%), Waste (20%) or Energy/GHG (24%). However, the general recognition of climate change and water scarcity caused us to evenly weight each of the impacts (25% each) for our upcoming MAT v2" (Nike, Inc. 2012a). Notably, material scores are tied to typical supply chain scenarios: for Spandex for example, fiber is assumed to be manufactured in South Korea and converted to finished fabric in China.[18] Use of these fixed baseline scenarios is especially interesting, considering that Nike has offered to contribute its MAT score database to the SAI.[19]

In the decisions and knowledge patterns behind the Considered Index, we can see Nike's focus on materials – both in terms of impact and innovation. Nike has a wide product range, and has strategically directed resources into materials R&D. Brand strategy is also extremely important at Nike. Relative to other companies, the Considered Index is well integrated into overall corporate responsibility goals, perhaps due to the value placed on coherence and consistency of the Nike brand.

2.1.2. Levi Strauss & Company: E-valuate

Background and purpose. Levi Strauss & Company (LSC) first developed Terms of Engagement for direct manufacturing contractors in the 1990s and early 2000s. Its standards have evolved over time, for example through the addition of a Restricted

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[18] For a discussion of geographic variability, see Steinberger, Friot, Jolliet and Erkman (2009).

[19] The MAT, now part of the Nike Materials Sustainability Index, is currently undergoing technical review by the SAC.

Substances List (RSL) issued in 2003. In 2007, LSC commissioned a comprehensive Lifecycle Assessment for two of its best-selling products, Levi's 501 Jeans and Dockers khaki trousers. Based on this analysis, LSC concluded that the greatest impacts in its typical product lifecycle came from raw materials and use/service. The company then began working on a lifecycle-based method for assessing the environmental impact of other products, which was named E-valuate and first released in 2009. In 2010, E-valuate was revised and applied to a pilot test of 40 fabrics and 11 products.

The stated purpose of E-valuate is "to enable LS&Co.'s designers and product developers to obtain high-level environmental impact information within a short period of time, as well as engage suppliers in the collection and tracking of related metrics to assess natural resources consumption and identify opportunities for improvement" (Gloria and Kohlsaat 2012). While the outputs of E-valuate are not directed in full toward consumers, LSC recognizes these outputs may be useful for supporting marketing claims.

Method design and development. E-valuate produces eight metrics of environmental impact, measured in absolute quantities, and four indicators given as percentages. These 12 impacts are organized into four equally-weighted categories: Climate Change, Natural Resources, Resource Efficiency, and Environmental Health. The E-valuate method emphasizes a science-based approach, and was developed with the assistance of a PhD-level LCA consultant. Currently the scope of E-valuate covers raw material production through manufacture (cradle to gate), although the intent is to eventually incorporate all lifecycle phases, from raw material to end-of-life (Levi Strauss & Co. 2011). In-house experts utilize GaBi software for new product evaluations, drawing on secondary data (i.e. industry averages) from lifecycle databases for the raw

materials phase. Primary data collected from suppliers is used, whenever possible, in materials and product manufacturing stages.

A points-based scoring system allows LSC to compare products to a chosen baseline, comparing results by performance percentile, in qualitative terms (good, better, best), or directionally (getting better/worse). This also allows the company to shift the baseline as industry standards change over time. The E-valuate method can be applied to individual products or to suppliers, comparing a vendor's performance to a baseline.

Discussion. Levi Strauss & Company has prioritized scientifically robust methods and the use of quantitative metrics whenever possible. It is transparent about the methodology behind E-valuate and committed to international standards such as the guidance on LCA provided by ISO. The thoroughness of this approach suggests that the outputs of E-valuate will be useful across syntactic boundaries, such as those found within a community of LCA practitioners. The use of quantitative metrics lends the tool to formal scoring, which we could expect to find in sequential work processes. E-valuate currently requires a significant amount of expertise, but LSC's efforts to translate the outputs into a more digestible scoring system – comparing performance percentiles to a baseline – should help make E-valuate more accessible to non-expert users.

LSC acknowledges the need for, and challenges of, providing timely, relevant information to designers while utilizing science-based methods and quantitative data (Gloria and Kohlsaat, 2012). From a designer's perspective, the thoroughness of the company's approach comes at a cost of speed and flexibility, as material composition and manufacturing processes must be highly specified in order to use E-valuate. On the other hand, Levi's has a limited product line relative to other apparel companies; most of its

garments are made from cotton. LSC's investment in two in-depth LCA studies yielded

results that are relevant to many of its other products, so at a high level the company is

able to discuss all phases of the typical product lifecycle, even though E-valuate ends at

product manufacture. Of the evaluation systems examined here, it is the only one to focus

attention on the use phase, which it presents to consumers through the Water<Less

campaign.[20]

Figure 4: Diagram of Information Flow by Lifecycle Stage in E-valuate
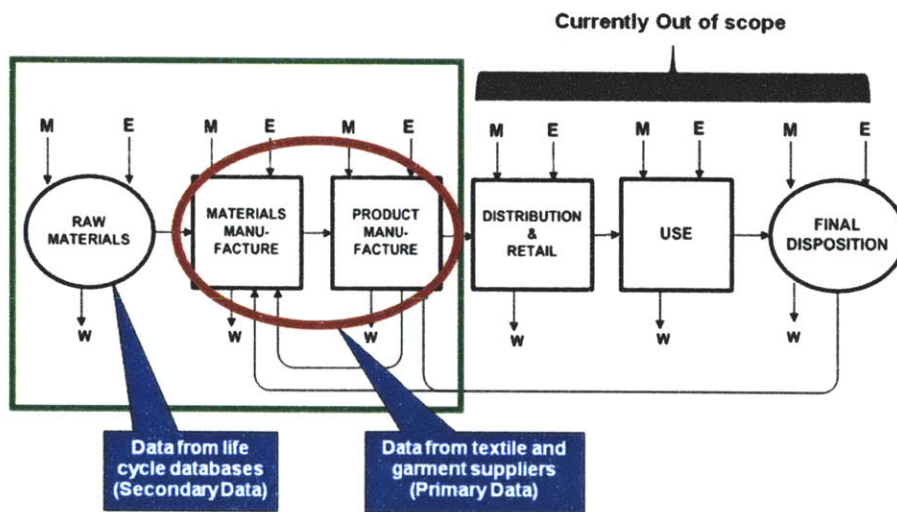
Source: Levi Strauss & Co. (2011).

2.1.3. Timberland: Green Index

Background and purpose. Timberland's first formal investigation of supply

chain impacts began in 2003, with a study of its classic yellow boot (Timberland 2009).

The analysis, conducted by Brown and Wilmanns Environmental, LLC, determined that

the boot's major impacts occurred in the raw materials extraction, materials production,

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[20] LSC is participating in the trial phase of Grenelle II, a French government labeling scheme for consumer products, which will be required for certain goods beginning in 2013.

and manufacturing phases. This study became the basis for launching the Green Index in 2007, which was substantially expanded in 2010. Timberland's stated purpose for the Green Index is: 1) to provide designers and developers with a relative measure of a product's environmental performance, so that they are empowered to make it better from the start; and 2) to provide consumers with a relative measure of products' environmental impacts to spur more sustainable purchasing (Timberland 2009). Timberland also wanted to support corporate environmental strategy by enabling consistent comparisons across product lines, with the original goal of putting a Green Index label on 100% of footwear by 2011.

Tool design and development. The Green Index is a three-part score, assessing Climate Impact, Chemicals, and Resource Consumption. Data inputs come from annual facilities assessments,[21] public databases, and product developers, who weigh each component of the product just after final sample production (see Figure 5). Climate Impact is measured using GaBi software and expressed in kg CO2-e; prior to launching the Green Index, outside LCA consultants from Five Winds International were engaged to provide training and consultation in LCA approaches and tools, including GaBi. For Chemicals and Resource Consumption, points are assigned on a 0-10 scale based on indicators such as percentage by weight of organic materials, and the total score is then calculated as an evenly-weighted average of the three sub-scores. The Green Index score is envisioned as a simple "nutrition label" providing quick information to both designers and consumers.

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[21] Factory energy consumption data is collected by Timberland Code of Conduct Specialists annually during their factory assessments.

The Index excludes packaging, transport, consumer use, and disposal phases; it also leaves out material waste from manufacturing, water impacts (due to lack of high quality industry data), and labor issues, which are monitored by Timberland's Code of Conduct and reported elsewhere. Even with these exclusions, Timberland found that designers and consumers needed faster and simpler indicators, so in 2008 it created a set of icons that indicate minimum standards of performance on seven specific criteria, ranging from Leather Working Group rating to use of recycled "Green Rubber" outsoles. In 2009 it also created a "Choice Grid" that gives designers a quick guide to estimating Green Index scores early in product prototyping.

Discussion. Simplicity has been a key value in Timberland's approach. The Green Index relies largely on secondary data sets, which Timberland sees as an advantage since these are publicly verifiable and "provide opportunity for external parties to use and repeat our methodology" (Timberland 2009). Professional judgment is embedded into the design of the Index, especially the ranking of impacts on a 0-10 scale. It requires users to make only a few decisions, trading off transparency and comprehensive reporting for the simplicity of a "nutrition label" style output. This approach makes sense considering the company's interest in reaching consumers. However, attempts at keeping the Index simple still have not met designers' needs; according to company literature, "Some of the most consistent comments from Timberland's designers convey their need for increased visibility to environmental attributes early in our product-scoring process... having materials' environmental data available when the material is chosen" (Timberland 2009).

Timberland's product icons and Choice Grid provide designers with certain shortcuts, but the company acknowledges that the real solution is integrating the Green

Index into the standard bill of materials (BOM) system used for all products. The IT required to achieve this integration would be quite expensive on its own, so Timberland aims to incorporate the desired changes into an already-planned technology upgrade. If successful, making environmental guidance available in the early prototyping stage would not only mediate semantic boundaries in the design cycle, but could also be useful at pragmatic boundaries – where collaborators have divergent interests, and need to negotiate the trade-offs involved.

Figure 5: Timberland's Green Index Rating Development Process
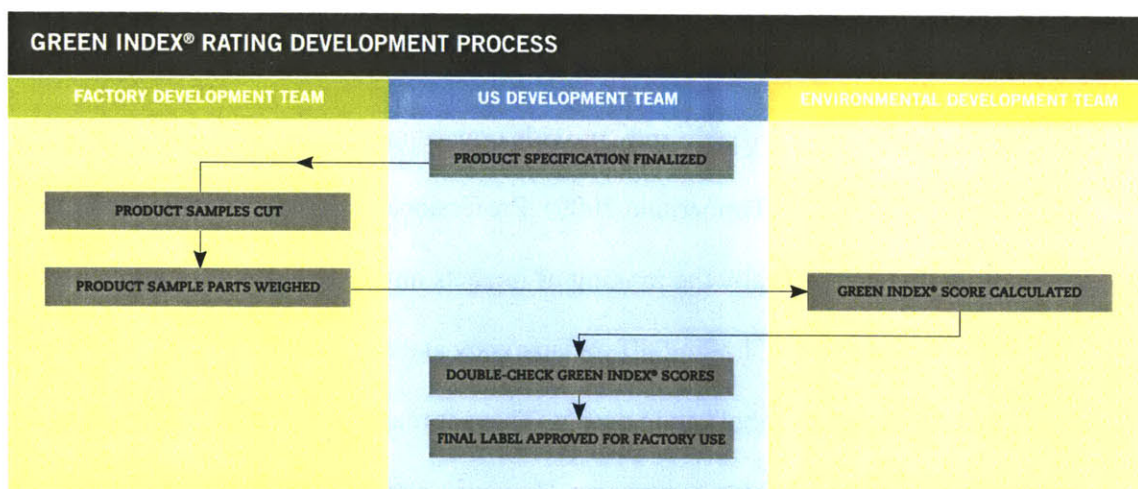
Source: Timberland (2009).

To summarize, the proprietary standards examined here take on a common challenge, of integrating environmental information into product design and development. They all cite the importance of a full lifecycle perspective, although in practice have prioritized certain lifecycle stages due to relative impact and/or availability of good data. Interestingly, none

so far has incorporated metrics for social factors such as fair wages or working conditions, instead addressing these issues through corporate social responsibility reports.

Table 3: Summary of Proprietary Standards and Major Components

	Nike Considered Index	Levi Strauss & Co. E-valuate	Timberland Green Index
Format of Tool/Method	• Direct interaction w/ Calculator interface	• Customized, product-specific analysis	• Custom analysis, use of Choice Grid
Interpretation (Information outputs)	• Good/better/best/ needs improvement scoring • Negative points possible	• Matches metrics to damage impacts • Sets baseline, defines good/better/best as percentiles • Equal weighting of 4 categories	• 1 overall score based on average of 3 sub-scores • Performance metrics converted to 0-10 scale
Product Choices (Decision inputs)	• Material type and quantity • 3 major process decisions	• Material type and quantity • Extensive production process information	• Material type and quantity • Use of PVC, solvent-based adhesives (yes/no) • Use of Environmentally Preferable Materials
Database	• MAT database • Scoring based on Restricted Substance List, Sustainable Chemistry Guidance • Integrated with other business processes	• Restricted Substance List • Secondary data used for Raw Materials	• Uses secondary inventory data in GaBi • Standard materials database searchable for EPMs
Data inputs	• Typical production scenarios linked to MAT	• Primary data on Materials manufacture, Product manufacture (when available)	• Measurements and estimates of facility energy use

While these in-house tools are composed of common building blocks, we also see significant differences among them. First, the tools target *varied audiences* that may include suppliers, product developers, CSR executives, and consumers, although all target designers. Second, comparison reveals a fundamental *tension between speedy and thorough analysis*, which each company resolves differently. We can expect companies

like Levi's to favor tools that embrace complexity, even at the cost of speed; companies

like Timberland will be more likely to prioritize simplicity, even at the cost of

thoroughness. Product range seems to play a role in this preference, with a more diverse

or fast-changing product line favoring more rapid analysis. Third, companies make a

choice to either rely on *secondary data*, often used in conjunction with expert LCA

software, or take on the challenge of collecting *primary data*, which is generally used in

combination with specialized databases or spreadsheets on the back end of a decision

tool. Finally, some standards *internalize* knowledge by embedding it into a tool that can

be used by non-experts; others rely heavily on *external* forms of expertise.

Given the specific nature of companies' needs and preferences, will more of them choose

to create custom tools? What are the prospects for a one-size-fits all index like the SAI?

2.2. Analysis of the Sustainable Apparel Index

To achieve widespread adoption and realize its full potential, the Sustainable Apparel

Index needs to directly benefit the individual companies that use it, in addition to creating

public goods. Impacts on internal workflow, decision-making, and knowledge systems

are not merely interesting, but will affect the success of any tool like the Index.

Raising the level of environmental intelligence in a product design department means

injecting new information into existing processes. There are choices to be made in the

way supporting data are collected and transformed into useful knowledge. Two of the

most critical decisions are:

Should we develop a custom standard, or adopt a shared tool?

and:

Do we care more about speed or transparency?

As we will see, the answer to the second question points to whether a company is more likely to favor "expert" tools such as LCA or simplified, non-expert tools. The answer also helps explain whether a company will be satisfied with increasing internal visibility, or favor externally-verified certification schemes.

To understand whether the SAI presents a strong value proposition for designers, interviews with apparel industry professionals investigated how brands currently integrate environmental knowledge into product design, noting examples of when that process works well or poorly. Since any tool that supports decision-making is itself supported by a system of knowledge, interviews specifically explored the inputs and outputs of environmental knowledge systems. Most interview participants had experience using an internally-developed standard or an early version of the Sustainable Apparel Index; only one participant had used neither type of formal tool. Questions were structured around three broad themes:

1) In the knowledge systems that support decision-making, where are companies making large investments in expertise, time, and/or financial resources?

2) What types and patterns of decision-making are found throughout the product creation process?

3) How can the Sustainable Apparel Index add value? When might it add cost or complication?

2.2.1 Knowledge Patterns and Decision-Making

To understand how the SAI can create net benefit for members, research interviews looked for signs of major investment in environmental capabilities. Pockets of major investment – whether in the form of time, money, or expertise – represent private resources that might potentially be shared by multiple companies, lowering the cost for all. For a company to raise its environmental capabilities, it needs an effective means for transforming raw data into actionable information, via Carlile and Rebentisch's concept (2003) of a "knowledge transformation cycle." The environmental knowledge or expertise used to complete this transformation may flow from external sources or be made internal to the company. In the absence of an industry-wide standard, interview participants traced their companies' **environmental knowledge** to the following sources:

LCA experts. Three firms employed Master's or PhD level experts in lifecycle assessment, whether as in-house staff or external consultants.

Chemistry experts. One firm had developed its own Restricted Substances List, and others reported that several apparel brands employed staff with chemistry expertise for the same purpose.

Corporate Social Responsibility (CSR) staff. Typically, CSR departments are located within corporate offices, organizationally separate from R&D/product development functions. Design and sourcing staff reported using CSR as a resource and/or needing to adhere to its policies, such as using only suppliers that have adopted the company's Code of Conduct.

Industry working group. Three companies were members of the Leather Working Group and/or Better Cotton Initiative. This commitment represents an

investment of staff time, in exchange for staying at the forefront of best practices in the industry and helping define common goals.

Decision-support tools. For the companies with experience using the Eco Index or a proprietary standard, the tool served as a repository of data (such as CO_2 emissions reported by suppliers) as well as expertise (such as the choice of performance levels and associated scores or weights). Formal tools typically require considerable investments of financial resources, such as Nike's reported $6 million investment in the Environmental Apparel Design Tool (Nike, Inc. 2010).

Institutional memory. Firms with no formal tools or metrics reported that knowledge was embedded in staff experience with factories, mills, or manufacturing processes, and that decisions in favor of "better" practices were often subjective and unsubstantiated. As one designer observed, "you just have to trust the cotton farmer, that they really didn't spray pesticides on that field." Another reported having "a general understanding of which materials are rated more highly…but I don't think we've ever done a really great job." A third participant attributed the firm's recent environmental performance improvements to its strong ties with cut-and-sew suppliers, which gave the firm access to detailed knowledge of manufacturing practices.

In addition, we should expect knowledge patterns and knowledge boundaries to favor certain decision-making tools, important situational dynamics for the SAI to navigate. Interviews yielded a number of key insights about **decision-making** in the product creation process:

Modes of collaboration vary throughout the product development cycle, and across companies. On closer inspection, the generic product creation cycle introduced in Section 1.2 involves many intermediate steps.[22] These elements include:

- **Market Analysis:** Defining and conveying broad strategy for product lines; communicating information about market conditions and business objectives

- **Design:** Generating possible concepts for new products; narrowing product concepts to be further developed

- **Development:** Refining ideas (including testing new materials/processes); defining technical specifications; commissioning and reviewing prototypes from factories; obtaining internal approvals, for example from Brand/Marketing

- **Manufacturing:** Deciding which suppliers to use; determining volume and timing of production runs

While most steps of the product creation process involve some form of collaborative interaction, approaches to collaboration and decision-making vary by work phase and by company. For example, a Director from Brand B said, "From a development standpoint, there are four key people on each team: a product manager, designer, sourcing manager, and product engineer. They work hand in hand throughout the process. We had tried more stringent hand-offs, but collaboration works better." This process would best be described as *reciprocal* work, requiring the simultaneous participation of four people with different spheres of knowledge.

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[22] As in any creative process, certain elements unfold in an iterative, cyclical way, rather than following a strict sequence.

In contrast, the same Director described pre-production approvals by saying, "Scoring is a fairly formal process. There's a brand committee, with four critical gates within the calendar, when the team brings proposals to the committee." This stage of the process could be described as *sequential* work, requiring clear lines of decision-making that are understood and respected by all. It follows that some stages of product design are naturally more transparent and participatory than others, and will require tools appropriate to the work type. Likewise, product design departments at some companies are more formal than others. We could expect, as a consequence, to see more formal companies favoring tools that produce quantitative scores.

Many types of boundary objects already exist within product creation. Common examples of boundary objects used to mediate interactions in the product cycle include: design briefs, coordination meeting agendas, Bill of Materials (BOM) documentation, specification packages for manufacturers, procurement contracts, Product Lifecycle Management (PLM) systems, and scoring systems to determine "fit" with brand identity. In order to effectively integrate social/environmental data and information into the existing process, it helps to first understand the types of interactions that these tools exist to support and mediate. While boundary objects serve similar purposes across firms, differences in internal cultures emphasize certain modes of interaction over others. For example, a designer from Brand A reported a frequent need to advocate for her product concepts: "Designers present to merchants, and have to convince them what to buy. Merchants have a really big role here."

Even within a single firm, different types of boundaries need to be bridged at different times. For example, prototyping is typically a highly collaborative stage, involving technical expertise of a product developer, know-how from a factory, and concepts generated by a designer. On the other hand, a brand review "gate" may involve design teams presenting to corporate managers with the power to veto ideas. Highly participatory stages require boundary objects that can mediate discussion across practice areas, similar to the CFD example from the automaker. Other decisions rely more heavily on authority, whether derived from position or expertise; in such cases, a formal score would be more useful than a conversation piece.

Tools for integrating environmental information into product creation, whether derived from formal LCA or lifecycle approaches more broadly, should be seen as boundary objects that will be understood by some parties more easily than others. Non-experts should understand the limitations of tools like LCA and what to do when uncertainties are uncovered.

Product-level decisions take place within larger relationships. The different parties involved in product design decisions can have very different priorities, incentives, and time horizons. For example, a sourcing manager may be concerned with her company's long-term relationship with a cut-and-sew factory, while a product designer just wants to source material for his company's first bamboo-fabric t-shirt. At Brand C, the prototyping stage involves many parties but outcomes are ultimately the product developer's responsibility: "The designer and product developer work in partnership with the factory

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to create prototypes. The developer manages that relationship." At this company, any database, guideline, or scoring system used during prototyping would therefore need to meet the needs of product developers, as well as designers. Similarly, it is worth considering which parties are best suited to collect the data needed to populate an environmental tool. As one participant reported, "we want our designers and developers to have really good relationships with the factories. Sourcing's job is to be the bad guy."

2.2.2 Benefits, Costs, and Complications

Interview participants who had used the SAI v1.0 were asked to reflect on where the SAI adds value to their organizations, and where it adds costs and/or complications. In some cases respondents discussed current sustainability challenges that the SAI does not address yet, but may in the future.

Adding Value: Benefits of the Sustainable Apparel Index

Interview participants commented on contributions the SAI was making toward improving their firms' performance. Responses clustered around four main themes:

Saving time and money. Several participants reported that it was valuable to have access to a database of fabrics and other materials rated for environmental performance. According to a Senior Director from Brand B, "the Material Index tool provided by Nike is extremely helpful." Literature on "club goods" suggests that sharing standards spreads the cost of their development among many parties; this is validated by Timberland's experience that "the OIA Environmental Working Group allows us to incorporate environmental performance data from supply chain partners...Breakthroughs in these areas could lead to significant reductions in the time and resources we currently

use to gather crucial data for informed decision-making" (Timberland 2009). These savings would be especially pronounced for small companies.

Setting the internal agenda. According to a Product and Supply Chain Analyst, "the SAI's most useful aspect is that it's a design guide at the product level. At the facilities level, it's a guide for our EHS department." In other words, given the complexity of sustainability issues, the SAI offers clarity and detail at the operational level for firms that want to improve their practices. Before entering any data or retrieving scores from the Index, the tool has value to such firms for its capacity to educate and facilitate conversations with internal stakeholders.

Addressing systemic issues. Given the dynamics of the industry, brands (especially smaller companies) are eager for ways to increase their bargaining power with contract manufacturers. As a participant from Brand C put it, "We all use the same manufacturers, so when you can work with them and say that several of your customers are asking for something – then you start to get supply chain leverage." The latest issue-specific initiative to support the "club goods" approach in apparel is the "Joint Roadmap" on hazardous chemicals issued by several major brands and manufacturers in 2011 (adidas Group, C&A, H&M, Li Ning, NIKE Inc., PUMA 2011).

Opening dialogue with external stakeholders. Index tools can be valued for purposes other than product-level comparison. Brand D uses its tool to get the attention of suppliers: "it is incredibly valuable for engaging with our suppliers. We use statistics to show them where they are in relation to competitors." Another participant pointed out that brands have the greatest incentive to report environmental information to consumers, more so than retailers or manufacturers.

Costs and Complications: Potential Pitfalls of the Apparel Index

Interview participants were asked for examples of challenges they faced in implementing the SAI. At the time of interviews the comment period for version 1.0 had just closed, and it was acknowledged that the SAC was already aware of certain challenges. Three main themes emerged from these comments:

Added costs in time and money. The SAI requires users to obtain primary data from material, packaging, and manufacturing facilities. Several participants noted that tracking down primary data is extremely costly and time consuming; the Apparel Index v1.0 provides space for up to 40 facilities. Even testing the SAI on one or two products required a significant time commitment; fully integrating it into a normal workflow was a daunting proposal for some. A participant from Brand B said, "As the tool stands now, my team can't possibly absorb it...companies our size need someone on board just to manage the SAI." A different type of cost reported by some had to do with the balance of power in supplier relationships. According to a Senior Director of Sourcing, "as a smaller company, we don't ask a ton from suppliers." Conversely, companies that purchase in high volume from their suppliers may have an easier time populating the SAI with the primary data it requires.

Capacity for LCA approach. The SAI is not LCA software; however, because it is based on an LCA framework it is designed to be comprehensive in terms of lifecycle stages and environmental impacts. One participant observed that it would be extremely challenging to conduct a thorough analysis on all of the company's products: "the apparel industry is one of the most poorly suited for LCA. If you walk into a department store, there are tens of thousands of different SKUs. Those products are changing over four

times a year." In addition, the degree of detail output from the SAI, and the timing of its availability, is a challenge for this manager: "We'd like to be able to give our designers/developers the info without taking them out of their work flow. If you take anyone out, you've lost the odds that they're going to participate."

Quality and availability of data. Even under the best circumstances, the quantity of primary data to be collected may be a challenge to implementing the SAI. In other cases, suppliers may be actually unwilling to cooperate in providing data. For example, a participant from Brand C explained that questions about marker efficiency could reveal inefficiencies that otherwise pad a manufacturer's profits: "factories may be concerned about losing margin with some brands." Other important impacts in the apparel industry, especially social considerations, are currently hard to capture with quantitative metrics.

2.2.3 Discussion

The brands examined here have all faced the following dilemma: will they increase their environmental capacity more by amassing company-specific data and deepening internal knowledge, or by putting their trust in outside sources of data and expertise? This study has helped dig into that question, and its general conclusions are summarized here. The next section will apply these general conclusions to the specific case of the SAI.

1) There are ways to make tools more user-friendly for designers, by paying attention to collaboration types and decision-making systems.

Across different companies, the specific patterns of knowledge and decision-making may vary, but most go through several common stages. Understanding these complexities,

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tools could be designed to better align with typical patterns of decision-making, improving their usability especially for designers. Important considerations include what elements of the tool will be used to inform individual decision-making, mediate group discussions, or support formal hand-offs.

Table 4: Expanded Typology of Decisions in the Product Creation Cycle

Phase	Concept Sketches	Design Development	Technical Development	Pre-production Approvals	Marketing
Sample Object	Materials library	Bill of Materials	Specifications Package	Scoring System	Product label or icon
Function of Object	Repository of data and experience	Describe product at detailed level	Communicate detailed instructions	Support decisions	Communicate message to consumers
Interaction Type	Pooled		Reciprocal	Sequential	
Added environ-mental capability	Quick comparison (materials/ components)	Understand full lifecycle impacts	Document best practices for future	Compare scores (whole product)	Quickly communicate relative performance

2) It is important to maintain existing workflow; embedding intelligence into tools and processes can help.

While lifecycle thinking is a widely accepted framework, performing a full LCA requires information that designers typically do not have, as well as time they may not be willing or able to spend. Non-expert tools for lifecycle thinking are therefore a legitimate need. A designer-oriented tool would align with the existing project workflow and help facilitate the kind of quick, directional decisions that need to be made during the design phase. It would help, for example, to populate the tool with default values so that missing variables do not block the output of results. Rather than relying on external sources to generate or interpret results, expertise should be built into the tool itself. Even better would be a

resource that is not a separate tool at all, but rather embeds environmental information into software and systems that design teams already use.

3) Efforts to share resources should focus on certain elements of knowledge and decision-making systems, where sharing will add the most value.

At its best, a shared standard can pool resources and lower certain costs, whether in terms of time, money, or expertise. Sharing a standard can spare companies from the cost of developing their own databases of materials and chemistry guidance, and of employing experts to develop custom methodologies. However, the lost specificity can impair the ability to conduct a full LCA, and may present other challenges to good practice, so should be approached with caution. Sharing the costs of data collection is another significant opportunity, especially in an industry where companies tend to use common suppliers. In some impact areas, third party certifications can be a valuable shortcut to direct primary data collection. Table 5 summarizes the general advantages (+) and disadvantages (-) of custom approaches vs. sharing data and knowledge/decision systems.

Table 5: Comparison of Proprietary vs. Shared Approaches

	Proprietary Approach	**Shared Approach**
Interpretation (Information outputs)	+ Coherence in weighting of impacts	- Need to allow users to assess trade-offs according to their values
Product Choices (Decision inputs)	+ Limited decision points can reflect company priorities	- Menu of choices will be long
Database	+ Store primary data specific to company + Integrate with other business processes	+ Share Restricted Substance List + Use industry average data as default
Data inputs	- Primary data collection is expensive	+ Reduce reporting burden on shared suppliers + Reference trusted 3rd party certifications

4) There is a key trade-off between speed and transparency, so shared tools should allow flexibility according to user preferences.

At some companies, the culture favors a high degree of transparency or visibility into supporting data. Designers at such firms may want to know they can see facilities-level primary data, or be able to override implicit judgments within an impact scoring scheme. In other design departments, the speed and simplicity of limited choices will be more valuable. Rather than validating product scores themselves, such firms may be more comfortable relying on databases and/or methodologies from a trusted party. An ideal tool would be flexible enough to accommodate users anywhere along this spectrum, allowing them to choose their preferred level of depth in data and methods.

We often associate highly participatory processes with openness and transparency. Counter-intuitively, in this case product lifecycle tools that are *more* opaque can invite greater participation by non-experts. Nike's Considered Index greatly simplifies decisions and "blackboxes" information, but is relatively approachable for designers. On the other hand, Levi's current version of E-valuate is more expert-oriented, limiting its accessibility to designers but offering transparency to the scientific community. How can we use this observation to improve environmental performance in the apparel industry?

In general, companies will face a decision whether to "make or buy" – or in this case, share – improved capacity for making sense of environmental impacts. Companies with a strong interest in and high tolerance for transparency will be more inclined to bring expertise in-house. These are the companies that will find it worthwhile to spend time

and resources on a custom solution. On the other hand, companies that are new to sustainability, small in size, or just interested in speed will be more likely to favor non-expert tools and solutions. They may be willing to trust information they didn't gather themselves, although would find trusted certification schemes especially valuable.

3. Recommendations

3.1. Future Scenario: SAI as Decision-Support Tool for Designers

Designers are not the only user group that needs a tool like the Sustainable Apparel Index. However they have been the focus here, and many companies share a vision of a future where environmental information is fully accessible and integrated with product design. As Timberland's Green Index Report puts it: "Our goal is for the Green Index® score to be considered in early prototyping stages for every product in Timberland's Product Lifecycle Management system...and calculated automatically at the sampling stage" (Timberland 2009). Another apparel company manager described early experience with the Apparel Index as follows: "When we went in, we involved product developers, since they are more involved in field testing and working with factories. But we realized designers made the key decisions. As the tool is currently designed, it's not designer friendly."

As described in general terms above, improving the prospects for designers will mean navigating critical trade-offs between simplicity and transparency, and understanding subtleties in the collaborative dynamics of product design. Any shared, industry-wide tool will be more likely to succeed when it meets the needs and desires of individual

companies and their product design teams. What this could look like more specifically for

the Sustainable Apparel Index is explained here:

3.1.1. Recommendation 1: To maximize the benefits of sharing, focus first on education, data collection, and databases.

An apparel brand's ability to conduct in-depth lifecycle analysis is a limited resource. For

companies with diverse and rapidly-changing product lines, it may not ever be practical

or desirable to build such capacity in-house. The SAC could help by investing

strategically in LCAs on certain products, and/or getting its members to share the details

of existing studies. Full LCAs on common garment types would help define the baseline

across companies, not just within companies, identifying impact "hotspots"[23] and areas of

high sensitivity and uncertainty.[24] Specific production scenarios will always be important

in LCA, but it may also possible to make some useful generalizations.

Building on Table 5, which compared proprietary and shared approaches, the benefits of

sharing may be more readily apparent in data collection and storage than in later stages of

knowledge "transformation." Currently, collecting data from suppliers to populate the

SAI is an onerous task; finding ways to provide incentives or make the process easier

would be welcome. A Restricted Substances List is a good example of a 'database' or

external reference that could be substantially shared across companies. Providing a

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[23] A good example comes from the home appliance industry, where the Association of Home Appliance Manufacturers, in cooperation with international safety company UL-Environment, commissioned several LCA studies to identify environmental priorities.

[24] For a suggested method for streamlining the LCA process, see Patanavanich (2011), Exploring the viability of probabilistic underspecificaton as a viable streamlining method for Life Cycle Assessment. Masters thesis, Massachusetts Institute of Technology. http://dspace.mit.edu.

boilerplate RSL would save time and resources; there may be other such modules of

information where the SAC can provide shortcuts.

Providing more "default" information would lower the degree of difficulty for new SAI

users. Analysis based on rough data may be of limited or directional use only, but it is a

starting point. Constituents who want more precise results could collect better data when

they have the resources to do so.

3.1.2. Recommendation 2: "Prime" the tool with information, then ask designers (only) questions they can readily answer.

The lifecycle approach is a scientifically sound framework for the Index, but structuring

the user's interaction with the tool by lifecycle phase adds complication, especially for

designers. In the current sequence, some information that is typically unknown until the

product development stage – for example, water use reduction in the dyeing process –

becomes an input to the Product Module. A designer using the tool can always indicate

"unknown", but added steps work against the goal of simplicity. In practice, there are

likely 4-6 key decisions that designers make, such as material choices, garment washes,

pattern efficiency, and care labels. Designers would be better served by building a

baseline concept product using only those limited variables, which they could then use to

easily compare alternatives for any one variable.

To streamline a designer's interaction with the Index, a company should populate it with data in a specific order:

Step 1. Input facility-level information where available, or use industry defaults where unknown. Procurement staff are probably the best suited to complete this step.

Step 2. Set company-specific defaults, in consultation with a Lead User from design. Pre-fill Index with choices, such as fabrics and packaging systems, typically used at the company. A technical developer may be the best person to guide this process.

Step 3. Product design teams interact with a simplified, visual interface that uses 4-6 key variables.

3.1.3. Recommendation 3: Give users richly layered, visual outputs.

In addition to simplifying the inputs – in terms of both data and decisions – that a designer is asked to make, it would be desirable to simplify the resulting outputs of the SAI. Achieving simplicity is challenging, however, because there are at least three dimensions of interest: 1) relative impacts of the six stages of the product lifecycle; 2) comparative measures or indications in seven impact areas; and 3) relative impacts of each material or process used on the garment. The combination of variables can be overwhelming, even to those trained in LCA. To further complicate things, designers want to know what happens when they try many different alternatives. Their use of tool therefore needs to be highly interactive, rather than producing a static report or snapshot.

Displaying the results of the SAI in a richly layered, visual way is one way to reduce information overload. An interesting example comes from the packaging industry, in the Comparative Packaging Assessment (COMPASS) tool developed by the Sustainable Packaging Coalition. The outputs of COMPASS, which are derived from SimaPro,[25] are displayed in color-coded histograms that communicate more than one impact dimension at a time (see Figure 6). Users can quickly read color and spatial cues, or click links in the tool to reveal numerical data. There is rich information in the results, but the user does not have to absorb it all at once.

Figure 6: Screen Shot from COMPASS
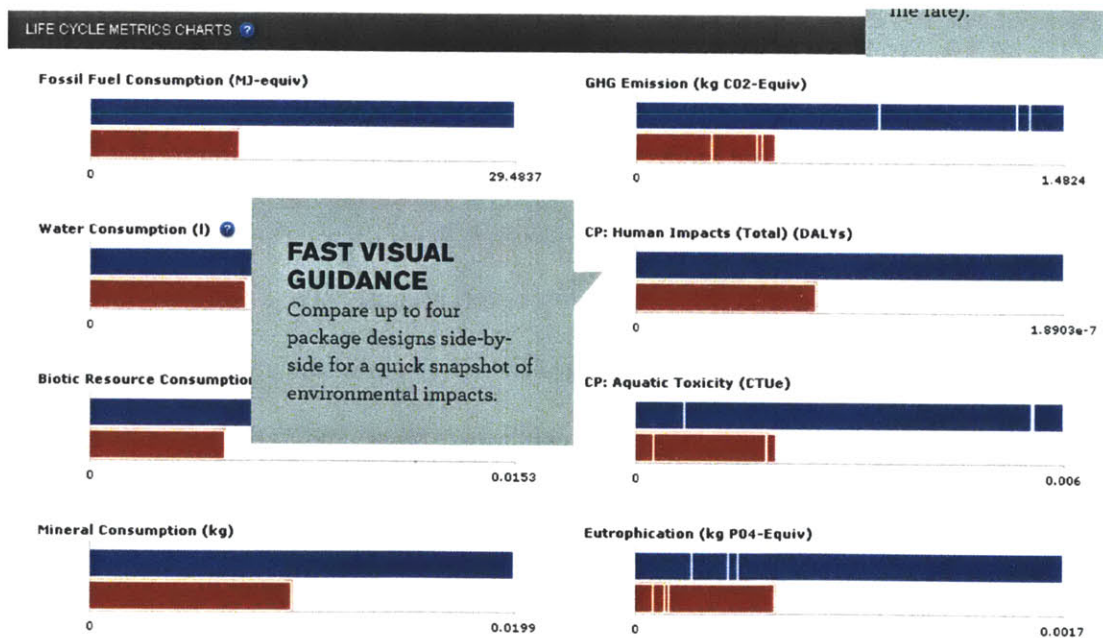
Source: Sustainable Packaging Coalition

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[25] An LCA software package.

In the earliest phases of the product cycle, when designers are sketching new ideas, it is especially important to access information and get results quickly.[26] "Scores" reported with colors or other visual means may be sufficient to give a designer what he or she needs to know to make a decision.

3.2. Future Research Directions

This study has attempted to observe the Sustainable Apparel Index as a work in progress, and suggest considerations for its future development. As more companies gain experience with the SAI and better data become available, future research projects might complement this one by undertaking more quantitative analysis. Some interesting questions to answer quantitatively could include:

- What is the optimal amount of precision in LCA work, in terms of costs and benefits to an apparel brand? What are costs of incremental degrees of precision?

- What is the cost of developing a proprietary LCA-based tool? Of building in-house capacity through expert consultants? What is the cost of adopting a shared industry standard, and is it less or more than alternative paths to enhanced knowledge?

- More specifically, for which components of a typical 'knowledge system' does sharing reduce costs? Is there a correlation between size of company and value of shared systems?

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[26] Other software tools that attempt to streamline product analysis with visual results include Quantis Footprinters and Sustainable Minds. See http://www.quantis-intl.com/footprinters.php and http://www.sustainableminds.com/software/when-and-how-to-use.

- What value do third party certifications add? When does a company want to rely on its own audits and assessments, rather than certification?

- What research investments by the SAC would offer the biggest bang for the buck, for example conducting full LCAs on "keystone" products? Which product decisions or variables exhibit the greatest sensitivity?

- How can the SAC aggregate primary data from member companies to continuously improve such baselines?

3.3. Conclusions

The Sustainable Apparel Index, and the Coalition that drives it, will be looked to as a precedent for other consumer goods industries. The observations gathered and filtered here should be relevant to other industries with long, global supply chains such as consumer electronics, toys, and furniture. The timeframes of consumer goods lifecycles are similar to each other (and different from those of fast-moving consumer packaged goods and longer-lived products like buildings); we should look for other similarities and differences, particularly in the pattern of impacts over the typical lifecycle.

Industry-wide coalitions are becoming more common, and if self-governed effectively can help whole industries leap forward in sustainability. To live up to their full potential the SAC, and other organizing bodies like it, will have to ensure that sharing a standard adds value at the firm level, not just to the public or the industry as a whole. Outcomes of participation should enable firms to support their larger corporate environmental strategy, and any tools should respect the firm's tolerance for transparency and expert use. Most

importantly for the constituency of designers considered here, new tools need to help, not hamstring, key decisions in the design and development cycle.

When is an Index Like an Iceberg?

The ideal Index tool would be scientifically robust, linked to primary data about each company's actual suppliers, fully transparent to those who want to verify methods, and yet clear and intuitive enough that designers can use it without breaking stride. Achieving this level of simplicity may only be possible by first managing the complexity under the surface of any Index tool. The analogy of an iceberg is fitting: 90% of the data and decisions may lie under the waterline, supporting a small but powerful set of levers that can best be manipulated during the design phase.

Non-expert use of lifecycle thinking tools is a legitimate need, especially among firms that value rapid design-stage analysis. Designers in such companies need lower barriers to interacting with tools built on solid LCA foundations. Some practitioners in the LCA field recognize this need and are working on streamlined approaches. However there may be a conflict of interest for some of them, if embedding LCA intelligence in user-friendly tools reduces the demand for external consultants.

Generally, we have seen that there is a tension between processes that externalize environmental knowledge, driving reliance on sources outside the firm, and processes

that internalize knowledge by building in-house analytical capacity.[27] In listening for

tendencies toward authority or participation in decision-making, we have heard a mix of

scientific consensus, professional judgment, and negotiated outcomes – a complex

political landscape for a seemingly objective tool. It is important to keep in mind,

however, that lifecycle tools are not magic wands and the boundary of who is inside or

outside the firm is not always so important. What matters is increasing capacity for

apparel companies, especially their design departments, to digest and act on relevant

environmental information.

By nature and disposition, product designers tend to be masters of a craft: intimately

connected with material properties, details of production, and the qualities that make a

product desirable. However product design is not a solitary vocation, but rather requires

negotiation, advocacy, and input from technical experts, to name a few types of

communication. Integrating deep channels of knowledge from outside their comfort zone

should not be an impossible challenge for product designers. An Index is simply a

platform for organizational learning, and as such can be built upon lessons learned from

studying other artifacts.

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[27] Some precedent exists for weaving "downstream" considerations into early stages of the product design cycle. The Design for Manufacturing movement challenged firms to integrate cost and quality considerations into design processes; some envision Design for Environment taking hold the same way.

Appendix: The Outdoor Industry Association Eco Index

The Eco Index is both the structural foundation of the Sustainable Apparel Index and its most important predecessor in terms of tool development and governance. The index is a project of the Outdoor Industry Association's Environmental Working Group (EWG), which formed in 2007 and has had representatives from 100+ companies.

The Index was designed to be used by companies with varied experience in sustainability issues, and therefore provides three levels of tools: Guidelines, Indicators, and Metrics The Guidelines are a set of qualitative principles and practices, intended to educate users who may have no previous experience addressing sustainability in supply chains. There are Guidelines for each stage of the product lifecycle, as well as general guidelines for product design and facilities. Indicators may be qualitative or quantitative, and can be used to assign a score to whole products or product components. Scoring is self-reported and based on points, awarded for practices that a company is undertaking. Finally, Metrics are quantifiable measures of performance. The latest version of the Eco Index's Footprint Metrics covered water, waste, and energy/GHG impacts throughout three lifecycle stages: materials, packaging, and manufacturing. Other impacts and lifecycle stages are considered out of scope for version 1.

Index Tools
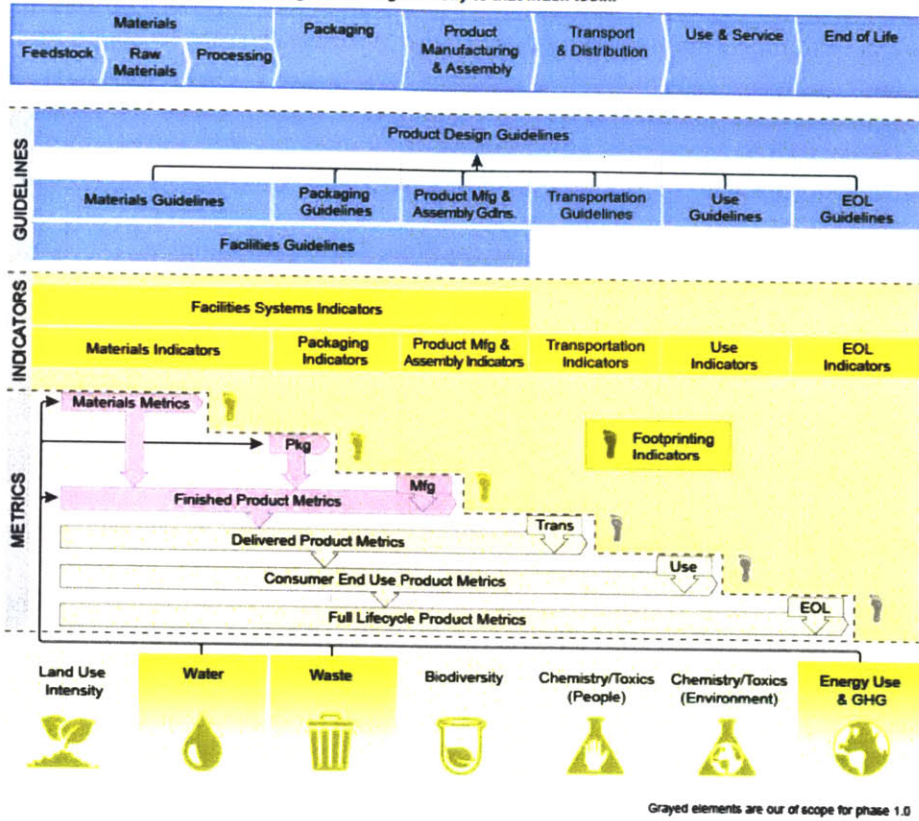
Users of the Eco Index Metrics populate an Excel workbook with data on materials and manufacturing processes. Product concepts need to be developed to the Bill of Materials (BOM) stage, as with most LCA tools. The Eco Index offers some data tables on GHG emissions factors but is flexible about the source of inputs: data can either come from supplier facilities or secondary databases. The vision is for data inputs to be dynamic, with primary supplier data replacing secondary data wherever possible, and for these data to be continuously updated as practices at supplier facilities change. Outputs are given as Finished Product Totals in terms of absolute quantities of CO2-e, hazardous waste, water consumption, etc.

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