harvesting and processing requirements (Fig. 4).  
• Not all environmentally preferred materials, such as water-based adhesives require an additional monetary expenditure.

The largest costs of savings include:  
• Replacement of poly suede/ leather with organic cotton.  
• Switching to water-based adhesives.  
• Replacing the use of primary rubber with re- 
    treads car tire rubber.

End-of-Life Evaluation

Table 2. Evaluation of EoL Options (Source: GaBi 4.0)

<table>
<thead>
<tr>
<th>Composting</th>
<th>GHG emissions (kg CO2 eq.) per pair</th>
<th>Additional</th>
<th>Avoided</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfilling</td>
<td>0.27</td>
<td>0</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Reuse</td>
<td>0.17</td>
<td>0</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Recycling</td>
<td>2.83</td>
<td>1.89</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>Grinding</td>
<td>0.04</td>
<td>1.52</td>
<td>-1.48</td>
<td></td>
</tr>
<tr>
<td>Composting</td>
<td>0</td>
<td>0.27</td>
<td>-0.27</td>
<td></td>
</tr>
</tbody>
</table>

The current EoL practice for shoes—landfilling—emits GHGs (mainly methane) during anaerobic decomposition of organic matter in landfills. Reuse would emit GHGs during transportation to the secondary user. Recycling would emit GHGs during transportation, disassembly, and reprocessing, but would save GHG emissions by avoiding landfill and primary production of footwear materials. Grinding would emit GHGs during transportation, but would save GHG emissions by avoiding landfill and primary production of surfacing materials. Composting, done by customers at home, would result in no emissions and would save GHG emissions by avoiding landfill (Table 2).

Conclusions

The LCA results suggest that the Green Toe shoes and ecoSNEAKS do have a lower environmental impact than the conventional shoe and that the Green materials initially chosen by Simple Shoes are the reason for this superior environmental performance.

“*Yes, a Green Toe shoe is simply better in terms of environmental performance than their other footwear products!*”

The supply chain analysis identified three points within the Simple Shoes supply chain that exhibited both high environmental impacts and for which Simple Shoes had at least a moderate amount of control:

• Material composition of the shoes  
• Manufacturing processes  
• End-of-Life management

Composting would be the best EoL management option for Simple Shoes because it has a negative contribution to GWP and is the most feasible alternative to landfilling.

Key Recommendations

• Simple Shoes should remove leather, synthetic materials, plastics and hybrids from their products.

• Simple Shoes should redesign their shoes to 100% biodegradable so that customers can compost the shoes rather than landfill the product.

References


Project Objectives

• Quantify and compare the environmental impacts of four shoes, two from the Green Toe line, one from the ecoSNEAKS collection, and one conventional Simple shoe.

• Analyze Simple Shoe’s existing supply chain using Life Cycle Assessment to identify opportunities for improvement in environmental performance and efficiency.

• Evaluate End-of-Life Management options based on feasibility and environmental performance.

• Recommend actions for Simple Shoes to further enhance their environmental performance.

Problem Statement

Given the success of the Green Toe line, Simple Shoes sought to systematically analyze the overall environmental impacts of their Green material choices.

“*Is a Green Toe shoe simply better in terms of environmental performance than their other footwear products?*”

Further, Simple Shoes sought to find additional methods and strategies to improve environmental performance along their supply chain and to assess the incorporation of End-of-Life management.

Introduction

Although footwear is not typically considered a commodity or industry that is particularly harmful to the environment, the sheer volume of shoes consumed each year generates significant environmental impacts. In 2004, 12 billion pairs of shoes were produced worldwide (Stairos, 2006). Traditional footwear uses both natural and synthetic materials. The production of petroleum-based synthetic materials is energy-intensive and involves the use of toxic substances; however the environmental performance of some natural materials is not considerably better.

For example, the production of 1kg of conventional cotton requires 26,100 liters of water, 16 grams of pesticides, 457 grams of fertilizers and 100 MJ of energy, and leather tanning releases chromium and other harmful chemicals (Cloud Institute, 2005). In addition to production impacts, many footwear companies have worldwide supply chains in which products are transported across the globe, burning fossil fuels that contribute to global warming.

Background Information

Simple Shoes began making shoes in 1991 and in 2005 set out to reduce their environmental impact by introducing a line of shoes made of Green materials.

This line of shoes is called Green Toe and features natural materials such as hemp, jute, organic cotton, bamboo, natural latex and crepe rubber, as well as recycled PET and recycled car tires. Thus far, the Green Toe line has been commercially successful and Simple Shoes is considering expanding the use of Green materials into their entire product line.
**Approach**

**Data collection** included discussions with our client to gather information related to material composition and weight, manufacturing processes (Fig. 1), costs and energy information and distribution networks.

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**Ten Environmental Impact Categories**

- Global Warming Potential (GWP)
- Human Toxicity Potentials (HTP)
- Marine Toxicity Potentials (MAETP)
- Terrestrial Toxicity Potentials (TETP)
- Freshwater (FAETP)
- Photochemical Ozone Create Potential (POCP)
- Ozone Depletion Potential (ODP)
- Acidification Potential (AP)
- Eutrophication Potential (EP)
- Radioactive Radiation (RAD)

The **Supply Chain Analysis** was performed to determine where Simple Shoes could modify its operations and decrease its environmental impacts. The assessment of Simple Shoes’ supply chain first involved learning about the stages and suppliers currently involved in the production of their shoes, as well as the distribution channels. We compared the supply chain of Shoe 4 (Fig. 2) to that of the Green Toe line to qualitatively assess the environmental and economic trade-offs.

**A Life Cycle Assessment** quantitatively measures the total environmental impacts of four of Simple Shoes’ products. The two Green Toe and one ecoSNEAK shoes (Shoe 1, Shoe 2, and Shoe 3) are composed primarily of Green materials, while the conventional shoe (Shoe 4) is made almost entirely of leather and synthetics.

We calculated the environmental impacts of each pair using GaBi 4.0 LCA software, created by PE International. The LCA measured the impacts from materials production, shoe manufacturing, transportation and disposal. This allowed us to determine which shoe has the highest impact and in what life cycle phases the majority of the impacts occur.

The GaBi software calculates the emissions from a product’s lifecycle and classifies these emissions into contributions to environmental problems called impact categories. We considered ten impact categories based on their acceptance in the LCA community and the interests of our client. The emissions to each impact category are normalized to total world emissions to enable comparisons across the categories.

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**Life Cycle Assessment**

The following table represents the LCA results for all four shoes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>0.0033</td>
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</tr>
<tr>
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<tr>
<td>4</td>
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<td>0.0179</td>
<td>0.0623</td>
<td>7.51</td>
<td>41.03</td>
</tr>
</tbody>
</table>

**Supply Chain Analysis**

With the use of a matrix to co-evaluate supply chain control and level of environmental payoffs we determined:

- Highest environmental impacts occur during the extraction and production phases of the materials, yet the only real control Simple has over these processes is in the quality of the finished material they purchase.
- Matrix also demonstrated that EoL management options have moderate environmental impact, yet currently Simple Shoes, has little control over these options.

**Results & Discussion**

- **Cost per lb.**
- **Conventional Cotton**
- **Organic Cotton**

![Fig. 4 Comparison of Cotton Textile Fabric Options](image)

The supply chain analysis also included an evaluation of material costs

- Price differential between the 4 shoes studied is primarily attributed to the materials used.
- Green materials, such as organic cotton are often more expensive than their traditional counterparts due to...