

Small Business Applications of Sourcemap: A Web Tool for Sustainable Design and Supply Chain Transparency

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ABSTRACT

This paper introduces sustainable design applications for small businesses through the Life Cycle Assessment and supply chain publishing platform Sourcemap.org. This web-based tool was developed through a year-long participatory design process with five small businesses in Scotland and in New England. Sourcemap was used as a diagnostic tool for carbon accounting, design and supply chain management. It offers a number of ways to market sustainable practices through embedded and printed visualizations. Our experiences confirm the potential of web sustainability tools and social media to expand the discourse and to negotiate the diverse goals inherent in social and environmental sustainability.

Author Keywords

Agriculture, Food and Drink, Hospitality, Life Cycle Assessment, Marketing, Participatory Design, Product Design, Small Business, Social Networks, Supply Chain, Sustainability, Transparency.

ACM Classification Keywords

K4.m Computers and Society. H5.m. Information interfaces and presentation.

General Terms

Design, Experimentation, Theory.

INTRODUCTION

We are at a critical moment in the pursuit of *sustainability*, or how to meet “the needs of the present without compromising the ability of future generations to meet their own needs [27].” Government and industry have proposed major sustainability initiatives; a bevy of popular media has emerged to guide consumers. But many important decisions are made at an intermediate scale, by entrepreneurs and professionals within larger companies. Whether planning a meeting, buying the ingredients for a meal or designing a product, the choices made in the professional world

constitute *design* – “the act of choosing among or informing choices for future ways of being [2].” *Sustainable design* can bring to market new products and services with long-term social and environmental benefits [17].

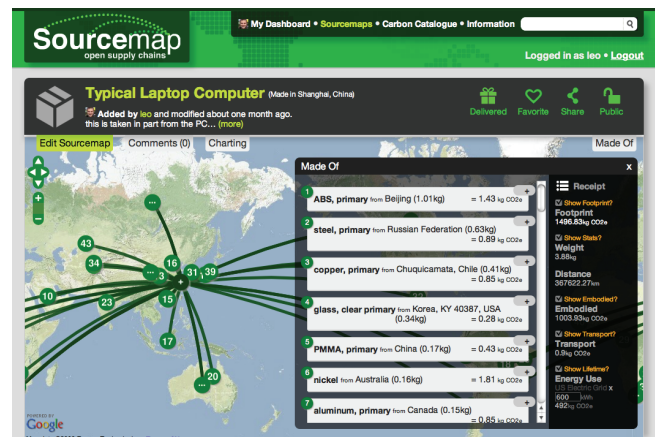


Figure 1. Sourcemap.

The practice of sustainable design relies on understanding the supply chains behind products and services—information that is out of reach for most people. *Supply chain transparency* is the disclosure of materials and processes and where they occur. A comprehensive approach to sustainable design compares potential supply chains to arrive at a solution that meets social and environmental goals.

We built a tool to support sustainable design and supply chain transparency, and we worked with sustainable small businesses to refine it. We embarked on five, year-long case studies that revealed multiple approaches to sustainability – social and environmental – rooted in underlying business principles (whereas *environmental sustainability* seeks to preserve natural resources, *social sustainability* is concerned with preserving social and cultural capital)[10]. The resulting web-based tool, *Sourcemap*, supports sustainable design through Life Cycle Assessment and supply chain transparency with shared visualizations (see Fig. 1). Its functionality was expanded to support many of the small businesses’ design strategies and to provide valuable communications functionality. The participatory design process also led us to consider ease of adoption and protection of privacy and intellectual property [8]. Our experience reinforced the need for free and open tools to

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support sustainable design and the need for communication channels to tackle these vast problems collectively.

This paper presents a survey of related work and our initial prototype, followed by five small business case studies and the discussion that inspired the current version of Sourcemap. It concludes with our findings and a presentation of future work in this new application space.

RELATED WORK

Sustainability remains a major concern as large groups announce sweeping environmental initiatives and we encounter a burgeoning crop of new media aiming to elevate public consciousness in this arena. Mandatory regulation has been very effective in spreading sustainable practices by restricting dangerous compounds and reducing pollution, waste and resource depletion [14]. Industry consortia are being formed to foster voluntary environmental accountability across supply chains [25]. Both approaches are rooted in *Life-Cycle Assessment* (LCA), a comprehensive method for evaluating the environmental impacts of products and services [9]. When implementing LCA, multiple metrics are considered, including risks to humans, animals, and the atmosphere, as well as social development indices [18]. Using expert tools, major institutions are able to conduct LCA to determine which parts of a supply chain to optimize for cost savings and/or environmental benefit. The results of these efforts are sometimes used to market ecological products [10].

As LCA takes a foothold in the private and public sectors, popular media and industry-sponsored efforts are shining light on many of the environmental and social aspects of supply chains. Product Life Cycle includes the extraction and refinement of raw materials, the manufacture of finished products, their transport, use, and end-of-life [9]. Popular films such as *The Story of Stuff* and *Blood Diamonds* highlight the extent of social and environmental impacts that stem from a product's supply chain [15,5]. Industry groups have also turned to public-facing media to reassure consumers in the face of problems related to the supply chain. The Kimberley Process was introduced by the UN to halt the distribution of *conflict diamonds*: gems originating in places where sourcing them may finance war [13]. In the wake of a BSE scandal, the Japanese beef industry turned to a computerized system including bar code-scanning kiosks in supermarkets to reassure consumers that the meat comes from healthy cattle [24]. Apparel manufacturer Patagonia publishes life cycle accounts of some products online, including the carbon footprint and the location of design, manufacture and assembly [20]. These public-facing efforts highlight the benefit of sharing the story behind products as part of marketing and quality assurance, and illustrate the growing importance of digital media to spread knowledge of sustainable practices.

Several interfaces targeted at consumers seek to advance sustainability by revealing the impacts of everyday choices. Web-based calculators, interactive visualizations and special hardware have been built to measure and display environmental impact and to motivate conservation at an individual level [1,12,16,26]. Some mobile applications guide consumers as they shop: a camera phone can be used to scan individual bar codes against an authoritative database of ethical and environmental indices [6,11].

In addition to large-scale sustainability initiatives and consumer guides, new tools could help entrepreneurs and small businesses practice sustainable design. A number of calculators exist for small businesses to track their "carbon footprint," similar to consumer-facing tools [22]. But small businesses are not only consumers: they have the capacity to contribute new products to the market, influencing sustainability choices of their customers and the strategies of their competitors. These smaller enterprises are unlikely to have access to sophisticated LCA tools or custom supply chain transparency software. Nonetheless their offerings can make a significant and sustained impact, and they are often in a position to communicate directly with their suppliers and their customers. We developed Sourcemap to spread sustainable design and supply chain transparency to small businesses so that this new audience can join experts in tackling the myriad of issues involved in sustainability.

DEVELOPMENT PROCESS

Sourcemap began with the construction of a web-based sustainable design tool for product design students (see *Prototype*). We developed a participatory design process that engaged small business owners over the course of a year (see *Case Studies*), during which time feedback and observations from their practice of design was incorporated into the project – a process which continues through the open source project under active development (see *Discussion and Development*).

PROTOTYPE

Sourcemap was originally built for students in an industrial design course as an introduction to the social and environmental issues associated with consumer products [3]. The simple website had two components: an LCA calculator and a drawing of the supply chain on a map. For each material in a given product, a user specified the weight, the type of material, its assembly origin and the means of transport. If applicable, he or she could enter the lifetime energy consumption of the product and its planned end-of-life scenario (recycling, re-use, incineration or landfill). The calculator computed a carbon footprint for each phase of the product's life, and a world map was constructed with each material at its source tied to a central assembly hub and to the location of the consumer. The geocoding used to draw the map was also used to calculate the carbon footprint caused by shipping. This automated shipping impact calculator brings out an often overlooked

factor that can make a product sustainable only within certain geographic bounds [7]. The map also serves as an intuitive gauge of a product's complexity, its "localness" and the countries involved in its production.

Several decisions were made early on to facilitate environmental assessment and to motivate users. Professional LCA software accounts for every input and output (typically hundreds) and measures impact in more than ten ways [21]. Sourcemap adopts a simplified approach inspired by the *Okala* method, which assigns normalized impact values to each material [19]. The impact value accounts for the environmental impact of extracting, refining, and shipping a material to the assembly plant, commonly dubbed 'cradle to gate.' We chose the measure of *carbon footprint* (also called CO₂e/Carbon Dioxide equivalent or Global Warming Potential) because it has become a household name and an industry standard. Sourcemap assigns a carbon footprint to commodity materials based on information gathered from publicly available sources [23]. Basic social functionality is included in the form of user accounts, rich text descriptions of each product and a sidebar that features comments. These functions were designed so that students could tell a story and visitors could learn more about each product through a direct conversation with the creator. The tool was used by two classes of 12 students each, and the experience was used to correct functional problems in the software.

CASE STUDIES

We visited five small businesses with a sustainability focus in the Scottish Highlands and in the northeastern United States over the course of a year. Each workplace is run by an entrepreneur (three women and two men) who is directly involved in day-to-day operations and helps maintain the business's website and web-based social networks. All of the companies have fewer than fifteen employees and generate less than 10 million dollars per year. These young business owners (between 30 and 45 years old) represent a generation of web-savvy entrepreneurs whose understanding of social media and the Internet makes these web portals an important part of marketing and sales. They employ varied sustainable design strategies that are unique expressions of their business ethos and a growing component in the discussion with consumers, suppliers and collaborators. During this year of investigation, each business was visited between two and four times as Sourcemap was refined on the basis of their suggestions and practice. In this section, we will introduce the five entrepreneurs, their business methods, and our interactions with them.

The Product Designer

The Product Designer runs an ethically and environmentally conscious studio producing hand-crafted specialty electronics and toys. Her products are "locally, ethically and environmentally crafted." She is interested in

demonstrating her efforts on the company's principal sales channel, its online store. Not all raw materials are locally available, however, so she needs a way to demonstrate that distant labor is necessary and ethical. She has traveled to India to document weavers working with traditional techniques, and wants to invest in preserving these endangered skills. The Product Designer suggested that we include rich media to describe each part of a Sourcemap entry, so that photographs and videos of the manufacture of every piece could be seen on the interactive map (see Fig. 2). It became apparent that a sustainable business strategy relies on documentation, and that a business can self-document practices as part of its presentation to consumers.

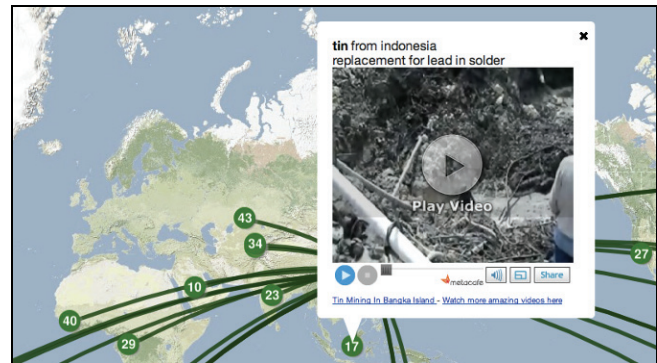


Figure 2. The Product Designer inspired the inclusion of rich media in the map to tell the story of each manufacturing step.

The Product Designer is expanding into retail sales, and she suggested that a printable version of the map be added to product packaging. These desires revealed a need for extensions to the calculators and visualizations of Sourcemap so that many designers could adopt the tool as an extension of their visual language.

As part of our study, the Product Designer entered each product she manufactures into Sourcemap. She reported a hurdle: some of the materials that she sources are hard to find, and this gives her a potential competitive advantage. Thus, the transparency imposed by geolocating parts on a map was a problem. In the short term, we have implemented a means of making individual maps "Private," so that they are not published online. In this way users can still use the tool diagnostically to account for carbon footprint internally, and there is an increased chance that, ultimately, they will make their supply chains transparent.

The Butcher

The Butcher grows native breeds of cattle on his family farm, selling the beef along with pork, lamb and game from neighboring farms at his small-town shop in the Scottish Highlands. Online sales represent the fastest-growing portion of the business, and he spends considerable time on the website and social networks. The Butcher has a very small geographic footprint: all of his products are made within 50 km of his shop; he knows all of his suppliers

personally. Many of his customers – both online and in person – buy his products because of his assurance of localized production and his verifiable supply chain.

Though the Butcher is fond of telling his story to walk-in customers, he is looking for ways to extend a social dialogue to his growing base of online consumers. His business has a rich website that includes recipes, news, and a growing presence on *Facebook* where he seeks to communicate more actively with customers [www.facebook.com].



Figure 3. The Butcher inspired a geolocating feature that accounts for the carbon footprint of shipping his products. On the left is his sourcing map; on the right is the map as it is viewed by an online visitor in London.

The Butcher is using Sourcemap to show the geographic reach of his operation and to account for the carbon footprint of his product. The first step was to create a map of his operations without any environmental data. This revealed the need to include customization features that allowed maps to be created for supply chain transparency separate from measuring carbon footprint. Next, the Butcher proposed embedding an interactive supply chain map in his online store to account for the footprint of specific products. Because most of his web sales occur in the south of England, he suggested that this embedded map also account for the footprint of shipping the product to each consumer (See Fig. 3). Finally, he proposed that the Sourcemap data be exported to *Facebook* to foster a conversation with his “fans.”

As we worked together to start accounting for the footprint of the meat sold in the store, the Butcher was surprised to find that the impact of producing meat was much greater than the impact from transporting it. The Sourcemap LCA makes it clear which portions of a supply chain have the largest footprint, so that users can direct improvements where they will be most effective. Despite being disappointed in this finding, the Butcher continues to account for carbon footprint because he sees it as a necessary part of an open dialogue with his consumers; and he believes that it will improve the image of his business and raise the standards of his industry.

The Butcher brought up a potential problem, however, with locating his suppliers on a map: the farm “is, in effect,

where they live.” Although it is unlikely that publishing their address will have negative effects in terms of compromised privacy, this makes an interesting case for devising approximate map locations while still providing enough supplier information to ensure traceability. This reinforced a common concern with the Product Designer: the need to carefully screen information to be presented on Sourcemap to protect suppliers and intellectual property while still conveying a complex and engaging story.

The Hotelier

The Hotelier owns and operates a three-star vacation hotel and restaurant on the banks of Loch Ness. Much of the tourism to the area is driven by its scenic landscapes, and her approach reflects an investment in the area’s natural wealth. In recent years she has taken steps to increase the environmental sustainability of the hotel, installing a wood chip heating system and participating in national and international green initiatives. She tracks how far guests have traveled to reach the hotel and offsets their carbon footprint by planting trees in nearby forests. She sources produce from local and organic farms whenever possible. The hotel’s philosophy and sustainability efforts are documented on its website, which she updates daily, along with a number of accompanying social networks. The hotel website includes embedded *Tripadvisor* widget showing unbiased (but largely positive) reviews from her guests; she is also considering a *Facebook* presence [www.tripadvisor.com].

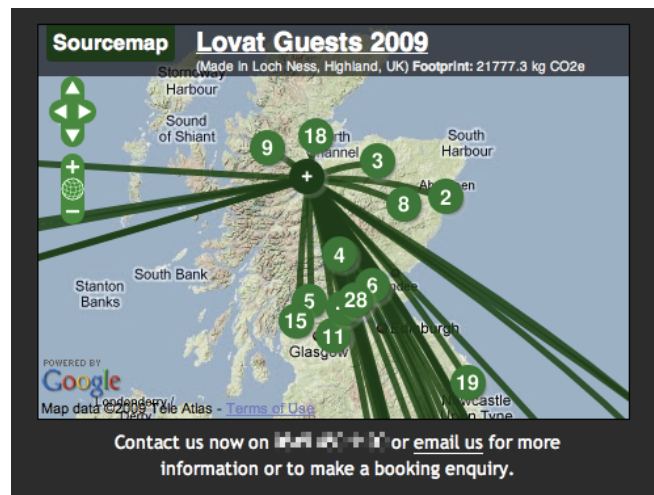


Figure 4. The Hotelier inspired the design of a travel template, which creates a badge of the carbon footprint of an event to which many people travel.

When the Hotelier first heard of Sourcemap, she suggested using it to visualize the paths traveled by her visitors, and to use the visualization on her website as a way of explaining her efforts to offset carbon footprint. This led us to refine an embeddable widget and to develop a template specifically for visualizing travel (see Fig. 4). She includes a Sourcemap embed of yearly travel footprint on the hotel’s

website, along with a description of the carbon offsets she has chosen to purchase. Based on her suggestions, we are also adding the capacity to include offsets to the Sourcemap interface so that conscientious businesses can present a badge of reduced global warming contribution alongside a description of their efforts. Her hotel now represents a carbon-neutral travel destination for all of her guests.

Later, the Hotelier proposed that the map could be used to assist in strategic planning for the hospitality industry of the region. Visualizing where guests originate from, where food is sourced, and which sites are visited could assist the region in overall development. Finally, she requested a streamlined input method whereby information could be directly exported from her existing database of guests to Sourcemap. These expanded functions further motivated the development of an extensible architecture with multiple points of entry to the Sourcemap calculators and visualizations.

The Brewer

The Brewer manages an independent cask ale brewery in a national park within the Scottish Highlands. Like the Hotelier and the Butcher, the Brewer believes that practicing business sustainably reinforces the image of the region and its products. Because the brewery operates within the confines of a park, minimizing waste and pollution is of the utmost importance. The Brewer has installed specialized machinery to re-use packaging materials and hot water, and she uses the social network *Freecycle* to find people that can re-use some of the brewery's by-products [www.freecycle.org]. Some of her beers are named for local interests, and a portion of profits is earmarked for issues such as wildlife preservation.

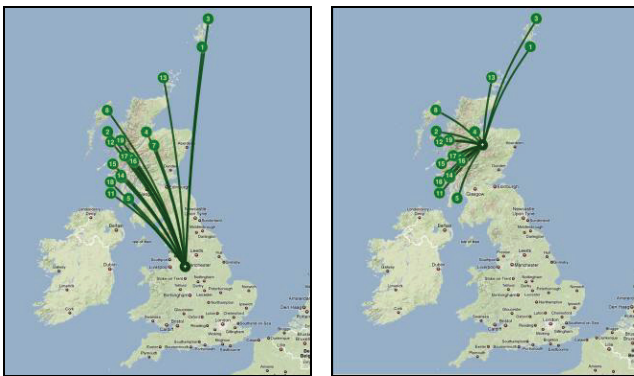


Figure 5. Beer in the Scottish Highlands is shipped to bottling plants in central England (left). The Brewer's proposed beer-bottling plant (right) could reduce the shipping of the region's beer from 6,500 to 3,000 km each way.

The brewery's location in a national park puts it close to many of its customers, but quite far from the nearest bottling plant. After speaking with several brewers in the Highlands it became apparent that operations are inefficient due to the lack of bottling plants in the region. As a result, each of the 18 breweries in the Scottish Highlands ships its

product to central England for bottling and back to northern Scotland to be distributed. A short-term approach would push production south, stripping already fragile areas of employment. The Brewer's long-term outlook is leading her to invest in a bottling plant on-site where her product and her competitors' products could one day be bottled. This plant will eliminate the brewery's footprint from shipping to the bottling plant, and it could halve the distance to a bottling plant for other brewers in the region (see Fig. 5).

The Brewer is not only motivated to reduce her carbon footprint: her underlying desire is to grow the community of these rural parts of Scotland. The decisions to eliminate waste and to invest in a bottling plant add important costs to her business, but they also represent nature conservation and employment opportunities. Her priority is *social sustainability* – investing in the communities of the region for long-term economic and cultural development. After mapping her operations on Sourcemap, she sought to source more ingredients locally. Barley, the principal farmed ingredient of beer, is not grown in the Highlands; so the Brewer is now working with local farmers to develop varieties that could one day be grown locally.

The Brewer was hesitant to widely advertise her carbon footprint until future improvements were implemented. When we showed her that Sourcemap allows for more nuanced story-telling about localized production patterns, she began using the site to show how the brewery re-uses materials, reduces waste and shrinks its carbon footprint through infrastructure improvements. These stories could help to attract customers and investors by presenting the brewery as an investment in the region.

The Caterer

The Caterer owns and operates a gourmet catering business dedicated to direct and local sourcing in the Boston metropolitan area. He takes care to source as many ingredients as possible from farms that are less than 250 miles (400 km) away; this limits his operation to the New England growing season, which runs from April to November. Thanks to a personal network of dozens of farms and farmers' markets, he is able to source nearly all of his ingredients locally during peak season. He explains his concern for local food with four arguments: he needs to ensure a safe and healthy source of ingredients; he wants to keep costs low; he believes in supporting ethical labor; and most importantly, he wants to make the best-tasting food possible. Nearly half of his clientele hires him because of his focus on locally-sourced ingredients.

Like the Brewer, the Caterer has a long-term strategy to reduce the footprint of his business and of his industry. He has invested in a fixed location for his kitchen in order to cut his travel footprint, and he is installing a distribution hub for locally farmed produce at this location during off-hours. This has the potential to benefit his suppliers, to reduce his and his competitors' dependence on industrially

farmed ingredients, and to create a carbon sink that can be reflected in his net environmental impact.

The Caterer initially suggested the idea of printing maps on the menus distributed at his catering events, and three generations of printable designs were subsequently used. Our first efforts – which were manually generated – showed that two maps are needed to document his sourcing (see Fig. 6). A local map illustrates the source of most ingredients with enough detail for customers to recognize the farm names, in case they want to buy the produce themselves. A global map locates those ingredients that cannot be sourced locally (e.g., olive oil, herbs and spices, and some fruits). The Caterer insists on showing both maps so as not to mislead his customers, and to highlight the relatively large number of ingredients he was able to source locally.



Figure 6. The Caterer suggested printable maps for his menus. These are the first two maps he used: a local map (top) and a global map (bottom).

The Caterer has used Sourcemap several times, noting a few changes in his behavior as a result. First, the map visualization revealed that several of his base ingredients – without which it would be difficult to make *any* meal – are sourced from distant and less-than-ideal locations. As a result, he is actively pursuing alternative sources for his grains and oils. Second, his team has begun to devise creative solutions to avoid ingredients that cannot be sourced locally; for example they are considering replacing cane sugar sourced from Latin America with maple syrup from New England. Third, using Sourcemap inspired him to provide custom maps on receipts as part of a new small-scale ‘pick-up’ catering business. The Caterer uses Sourcemap as a strategic design tool and as a marketing tool in printed menus and on his website.

Although revealing his sourcing strategy makes it easier for his competitors to imitate him, the Caterer believes that the relative benefits he will garner from publicity, bolstering his suppliers’ businesses, and being an early adopter outweigh the risks posed by imitators. In fact, he uses Sourcemap in part to stand out from the growing crowd of restaurateurs claiming to source locally without specifying which ingredients are sourced where. Like many of the other participants in our study, the Caterer believes that an open dialogue – in which both the positive and the negative are revealed – is fundamental to gaining trust from his clients and furthering the state of his industry in general. He even suggested that we include a template for other restaurateurs to use Sourcemap with a customized set of options specifically for food.

DISCUSSION AND DEVELOPMENT

The case studies transformed Sourcemap from a simple sustainability calculator into a tool for transparency, communication and marketing. We tackled usability issues to adapt LCA for specific industries, to ensure accurate entries and to make impact measures more intuitive. The map visualization provoked a number of applications, which we support through different customization options. Most of all, the small businesses revealed the importance of social functionality, especially marketing, to motivate sustainability and transparency efforts. Over the course of development, it became more apparent that collective use of the site would increase value, accuracy and trust, and we pursued this goal with a free, open, and flexible architecture. This approach unifies the pursuits of sustainability and transparency and moves us toward a general template for sustainable development that could be useful in a number of industries.

Usability

One basic design challenge of Sourcemap is to make LCA widely practiced and easily comprehensible. This relies partly on ensuring accurate entries and providing an intuitive scale of value. Early observation of users’ activity showed that many fields were confusing or left blank. Sourcemap now has different templates streamlined for individual applications. The accuracy of the forms is reinforced by various types of guidance. Another problem has been the ability to understand the relative impact of different decisions. These impacts are reflected at multiple levels: within the underlying ‘Parts Catalogue,’ in the cumulative ‘Caron Receipt’ and in the interactive map (see Fig. 7).

Templates

As suggested by the Hotelier and the Caterer, users are now presented with a different template depending on whether they want to map a product, a food, or a trip. A user selects a template from the Sourcemap home page, whereupon she is taken to a Sourcemap editing interface to specify each of the ‘parts’ of an ‘object,’ the ‘ingredients’ in a ‘meal,’ or

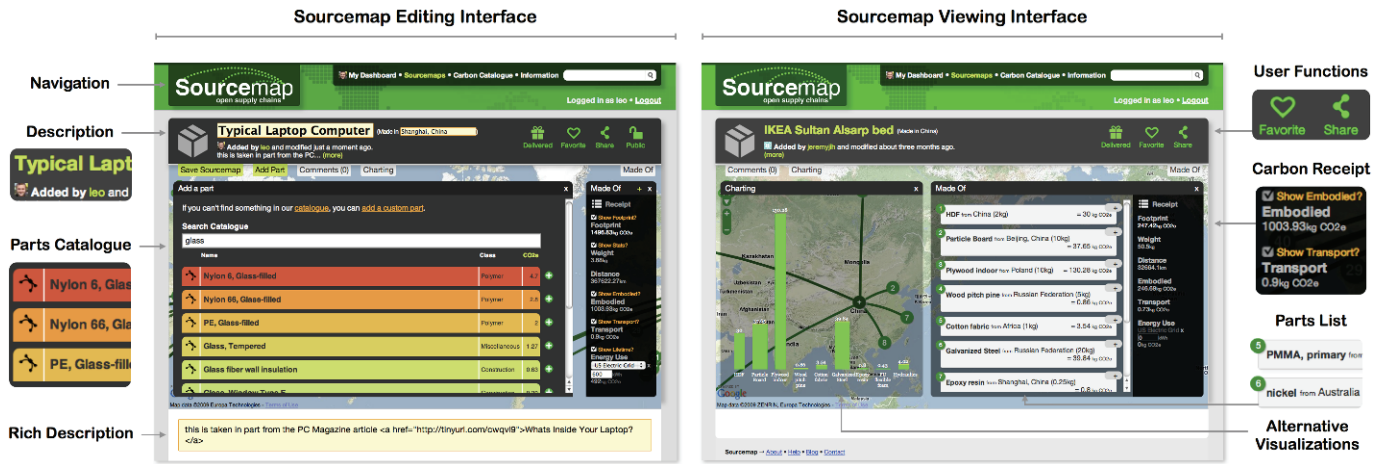


Figure 7. The Sourcemap Editing Interface (left) and Viewing Interface (right).

the “passengers” on a “trip.” A travel map only considers the impact of shipping; a food map considers both shipping and growing; a product map includes all phases of a life-cycle. The food template only considers a database containing edible ingredients. The travel template counts individual passengers using the normalized weights employed by the travel industry. These streamlined templates can reduce the number of text fields by half or more while guiding users through a new kind of environmental accounting inspired by sustainability practices within their industry.

Guidance

Among the usability problems we observed, the omission of information and non-standard ways to describe locations resulted in the most errors. A guided approach ensures that entries are created properly. Once they have selected a template, users are taken to an initial Sourcemap editing screen where they enter the name, assembly location and description of the entry. Geolocation feedback verifies that the intended locations have been recorded. Then, a special version of the editing interface appears with the “Add a part” window pre-loaded.

Parts Catalogue

A basic goal of using LCA software is to choose those materials and processes with the least impact. In the “Add a part” window, a dynamic searchable list of materials can be filtered by name, type, or description, and sorted by carbon footprint. In many cases, this “Parts Catalogue” also contains “flags” describing other important concerns (such as toxicity). The list is color-coded to provide an intuitive understanding of relative impact. Once a material has been selected, it joins the numbered “Parts List” where users supply additional information, including weight, origin, means of transportation, and a description. At any point, the user can add, remove and edit parts from this list.

Interactive Map

Sourcemap introduces a novel way to see an entire supply chain at a glance: the interactive “flight path” map with information about every part and its origin. As a part is added to an entry, a numbered dot appears on its location on the map. The dot can be clicked to bring up a bubble containing text, photograph or video descriptions. To address privacy concerns, the dots can be located on specific addresses and GPS coordinates, or they can have vague place names (Such as New York City or France). This information remains useful to calculate the distance the object has likely traveled. The map’s boundaries shift as more of the world is involved, so a locally-sourced product has a very different map than a globally-sourced product has.

The map is not an accurate reflection of the paths taken by the parts in a supply chain, but instead a graphic index of their number and origin. In real supply chains, parts will usually have multiple stops on their way to the end consumer. Commodity materials can be mixed from multiple sources. Raw materials are usually shipped by a combination of land, sea and sometimes air. We are working to include these variables to improve the accuracy of our shipping impact calculation, and to make it possible to see the actual paths traveled, although the classic map will likely be preserved for legibility.

Carbon Receipt

As part of the LCA feedback that helps users understand which phases of a product’s life cycle have the greatest impact, a “Carbon Receipt” alongside the “Parts List” is continuously updated with the carbon footprint of each phase of a product’s life cycle: embodied, shipping, use, and end-of-life. Often, food products have a significant global warming contribution from shipping and packaging. Consumer electronics, conversely, are more energy-intensive to produce, and, different still, are automobiles,

which produce the bulk of emissions during use. On the other hand, locally-sourced foods have little packaging or shipping, electronics that are refurbished have more impact from use, and electric vehicles can have a more substantial impact during manufacture. Visualizing these sometimes-counterintuitive relationships is an important way that the “Carbon Receipt” supports sustainable design.

Customization

The case studies showed that a Sourcemap entry can have multiple uses: in the case of the Brewer, the Butcher and the Caterer, it highlights a small geographic footprint; in the case of the Hotelier, it serves to measure travel emissions; and for the Product Designer it tells a story about her craft. Each approach promotes a unique type of social or environmental sustainability that reflects the priorities of the business, its consumers and the community. To accommodate different approaches, we have gradually introduced two kinds of customization to Sourcemap entries: private entries and a customized “Carbon Receipt.” Many users – including the case study participants – worked on several draft versions of their maps before printing them or publishing them online. For these reasons, Sourcemap entries can now be marked “Private” and not appear in public searches.

The diverse uses of the Sourcemap visualization led to a customizable “Carbon Receipt” in which only those parts of the life-cycle relevant to a particular story appear publicly. In a map used to document supplier locations, for example, no footprint is measured. Where travel is depicted, only shipping is considered, and where food is shown, only embodied and shipping are accounted for. By selecting checkboxes alongside each life-cycle phase in the “Carbon Receipt,” users can choose how the footprint appears publicly. Although users could use the checkboxes to omit relevant information, the symmetric design of the interface makes it clear when someone has hidden potentially relevant information.

Social Functionality

The pilot studies revealed the type of social channels relevant to sustainable small businesses and their underlying motivations to connect with consumers. Sourcemap now offers a number of ways to export information for marketing and communication needs, as well as to engage in a larger discussion with consumers, the World Wide Web, and experts in sustainability.

Printable Map

As suggested by the Caterer and the Product Designer, Sourcemap entries can be printed on documents and packaging. A “Print Map” option generates a dual map (local/global) with legend. In the future, we will offer ways to customize the map, including a vector version suitable for etching onto products themselves.

Embeddable Map

As suggested by the Hotelier, Sourcemap entries can be embedded into external websites as an *iframe* (see Fig. 4). The embeddable map is simplified: it only shows an interactive map with the title, footprint and description. Users can click through to visit the complete Sourcemap entry where the calculations and parts list are detailed. This extends the visibility of a map to countless other websites, including the small businesses themselves, without cluttering them with the minutiae of LCA.

Alternate Visualizations

Sourcemap entries can be exported in a number of different ways, including raw data for use by developers. Pie charts and bar graphs can be used to visualize the relative impact of different phases and materials. The map data can be exported to Google Earth, as a JSON file or as comma-separated values (csv) file.

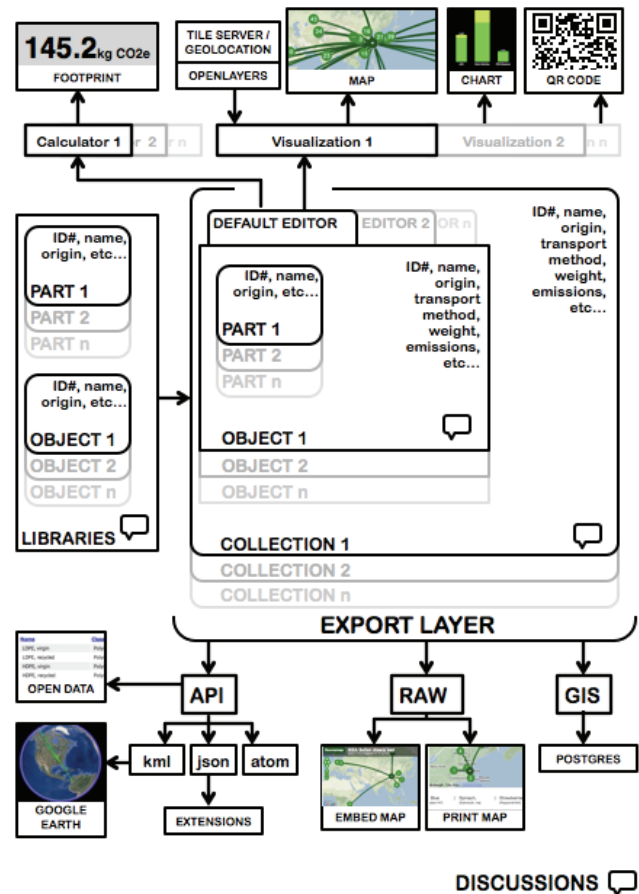


Figure 8. Sourcemap has a modular framework to support extensions and additional tools. The system supports multiple editors, calculators, visualizations and templates. All of the data and calculations are available through an open API that allows any system to make use of Sourcemap features.

User Functionality

Inspired by Youtube and other social media sites, the content creation process in Sourcemap uses the familiar

structure of *users* with administrative *dashboards* and the ability to *comment* on and *favorite* other users' entries [www.youtube.com]. Though the site is still primarily used for one-way broadcasting by students and small businesses, we hope that this new functionality will foster large-scale discussions and draw in the voices of environmental and social sustainability experts.

Openness

Sourcemap is based on a collective approach to environmental assessment and supply chain transparency where the tools and the data are contributed by a worldwide community of users. This is rooted in a belief that sustainability is more readily achieved if the information and the tools are freely available to use and to modify. Sourcemap is an open source project licensed under the GPL; the software platform and the user-contributed data can be copied, re-created and modified. A symmetric design opens the site to occasional users or visitors: the interface used to create an entry is the same as the interface used to view it. This is intended to elevate the discourse around sustainability by making all of the underlying assumptions and calculations widely available.

Special considerations have been taken to help foster a community of contributors including users, developers and sustainability experts. Sustainability practices are continually evolving, and Sourcemap is extensible so that new calculators and visualizations can be included to reflect yet-to-be invented strategies for sustainable design (see Fig. 8).

CONCLUSION

The participatory design process consisted of a series of negotiations: between the Sourcemap team and the case study participants, between social and environmental sustainability, and between business values and sustainable ideals. Our prototype framed a dual discourse around LCA *and* supply chain transparency, but only the Hotelier and the Butcher used it to calculate carbon footprint, whereas all of the participants found something to express through the supply chain visualization. The map was more flexible, allowing the participants to address their underlying social priorities, bringing to light social sustainability strategies we had not anticipated. These issues sometimes conflict with traditional concerns of environmental sustainability. For example, centralized production is usually more efficient and has a lower carbon footprint; it also has the potential to strip fragile areas of jobs and endanger cultural resources. Small businesses are uniquely positioned within sustainable practice: they often benefit from promoting local interests and their simpler sourcing and responsiveness to consumers lowers barriers to implementing carbon accounting and supply chain transparency. The widespread adoption of sustainable design techniques and the use of carbon footprint as a valuable environmental, social, and economic metric will

require greater public consciousness and more intuitive standards.

There are a number of potential conflicts between carbon accounting based on supply chain transparency and concerns of privacy, intellectual property and confidentiality. In the short term, the practice of disclosing sourcing is so novel that it is rarely expected. Accurate disclosure of carbon footprint is only possible if it can be verified, so it seems necessary that the underlying data should be publicly available. Although we have made concessions to the vision of total transparency in order to foster adoption, Sourcemap seeks to establish a model for the type of disclosure we should one day expect from our suppliers and provide to our customers. While the current use of Sourcemap is motivated by the desire to stand out from the competition by marketing transparent and sustainable practices, we imagine a future where this level of transparency is a necessary part of doing business.

FUTURE WORK

Sourcemap.org has developed a growing user community, one which will allow us to evaluate the site as we continue to develop new functionality and refine existing elements. One of our main priorities is to enhance social networking features throughout the site. We hope this will help to improve the quality, accuracy and number of entries. The Sourcemap team is also pursuing additional participatory design projects together with regional groups, industry consortia and larger companies. There are a number of promising directions for future development, especially the inclusion of tools to compare along multiple parameters, such as along social indices or financial cost. Contributors to the project are beginning to add new types of visualizations and calculators and we are developing functions especially for educators, journalists, researchers and sustainability advocates within large enterprises. In the long term we hope that Sourcemap will become populated with enough materials and supply chains to serve as a general resource for large-scale sustainability and supply chain management.

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REFERENCES

1. Arroyo, E., Bonanni, L., and Selker, T. 2005. Waterbot: exploring feedback and persuasive techniques at the sink. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Portland, Oregon, USA, April 02 - 07, 2005). CHI '05. ACM, New York, NY, 631-639. DOI=<http://doi.acm.org/10.1145/1054972.1055059>
2. Blevis, E. 2007. Sustainable interaction design: invention & disposal, renewal & reuse. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (San Jose, California, USA, April 28 - May 03, 2007). CHI '07. ACM, New York, NY, 503-512. DOI=<http://doi.acm.org/10.1145/1240624.1240705>.
3. Bonanni, L., Parkes, A., and Ishii, H. 2008. Future craft: how digital media is transforming product design. In *CHI '08 Extended Abstracts on Human Factors in Computing Systems* (Florence, Italy, April 05 - 10, 2008). CHI '08. ACM, New York, NY, 2553-2564. DOI=<http://doi.acm.org/10.1145/1358628.1358712>.
4. Bonanni, L., Hockenberry, M., Pak, A. and Ishii, H. (2009) Tools for Collective Simulation. In: *Proceedings of the WebSci'09: Society On-Line*, 18-20 March 2009, Athens, Greece.
5. Blood Diamond. Dir. E. Zwick. Warner Brothers, 2006.
6. Dada, A., Graf von Reischach, F., and Staake, T. Displaying Dynamic Carbon Footprints of Products on Mobile Phones. In *Adjunct Proc. Pervasive 2008*, 119.
7. Dada, A., Staake, T., and Fleish., E. The potential of UbiComp technologies to determine the environmental footprints of products. *Workshops Proceedings of the Sixth International Conference on Pervasive Computing (Pervasive 2008)*.
8. Dourish, P. 2006. Implications for design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Montréal, Québec, Canada, April 22 - 27, 2006). R. Grinter, T. Rodden, P. Aoki, E. Cutrell, R. Jeffries, and G. Olson, Eds. CHI '06. ACM, New York, NY, 541-550. DOI=<http://doi.acm.org/10.1145/1124772.1124855>.
9. Giudice, F., La Rosa, G., Risitano, A. *Product Design for the Environment: a Life Cycle Approach*. Boca Raton: Taylor & Francis, 2006.
10. Goleman, Daniel. *Ecological Intelligence: How Knowing the Hidden Impacts of What We Buy Can Change Everything*. New York: Broadway Books, 2009.
11. Good guide: <http://www.goodguide.com/>
12. Goodman, E. 2009. Three environmental discourses in human-computer interaction. In *Proceedings of the 27th international Conference Extended Abstracts on Human Factors in Computing Systems* (Boston, MA, USA, April 04 - 09, 2009). CHI EA '09. ACM, New York, NY, 2535-2544. DOI=<http://doi.acm.org/10.1145/1520340.1520358>.
13. Kimberley Process: <http://diamondfacts.org/>
14. Life-Cycle Regulations include RoHS (<http://www.rohs.gov.uk/>), ISO 14001 (<http://www.iso.org/>) and the Green Dot (<http://www.gruener-punkt.de/>)
15. Leonard, A. *The Story of stuff*: <http://www.storyofstuff.com/>
16. Mankoff, J. C., Blevis, E., Borning, A., Friedman, B., Fussell, S. R., Hasbrouck, J., Woodruff, A., and Sengers, P. 2007. Environmental sustainability and interaction. In *CHI '07 Extended Abstracts on Human Factors in Computing Systems* (San Jose, CA, USA, April 28 - May 03, 2007). CHI '07. ACM, New York, NY, 2121-2124. DOI=<http://doi.acm.org/10.1145/1240866.1240963>
17. McDonough, W. and Braungart, M. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002.
18. Norris, Gregory A. Social Impacts in Product Life Cycles: Towards Life Cycle Attribute Assessment. *International Journal of Life Cycle Assessment* #11, Special Issue 1(2006), pp. 97-104.
19. Okala LCA approach: <http://www.idsa.org/>
20. Patagonia Footprint Chronicles: <http://www.patagonia.com/web/us/footprint/>
21. Simapro LCA software: <http://www.pre.nl/simapro/>
22. Small business carbon footprint resources include: The US EPA Climate Leaders Small Business/Low Emitter Tool (<http://www.epa.gov/>); Clean Air-Cool Planet Office-Based Carbon Footprint Tool (<http://www.cleanair-coolplanet.org/>); Ratcliff Greenhouse Gas Calculator for Facility Operations (<http://www.ratcliffarch.com/>)
23. Sourcemap Carbon Catalogue: <http://blog.sourcemap.org/methodology/references/>
24. Souza Monteiro, D., Caswell, J. A., *The Economics of Implementing Traceability in Beef Supply Chains* (June 2004). University of Massachusetts, Amherst Working Paper No. 2004-6. Available at SSRN: <http://ssrn.com/abstract=560067>
25. Walmart Sustainability Consortium: <http://www.sustainabilityconsortium.org/>
26. Wattzon provides the capability to compare one's own energy footprint to a library of user-contributed products and lifestyles: <http://wattzon.org/>
27. World Commission on Environment and Development, *Our Common Future*, Oxford University Press, 1987.