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Article

Efficient Assessment of Social Hotspots in the Supply Chains of 100 Product Categories Using the Social Hotspots Database

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Abstract: Data collection, or the inventory step, is often the most labor-intensive phase of any Life Cycle Assessment (LCA) study. The S-LCA Guidelines and numerous authors have recommended generic assessment in this first phase of an S-LCA. In an effort to identify the social hotspots in the supply chains of 100 product categories during just a few months' time, adopting a streamlined approach was essential. The Social Hotspots Database system was developed by New Earth over 5 years. It includes a Global Input Output (IO) model derived from the Global Trade Analysis Project, a Worker Hours Model constructed using annual wage payments and wage rates by country and sector, and Social Theme Tables covering 22 themes within five Social Impact Categories—Labor Rights and Decent Work, Health and Safety, Human Rights, Governance and Community Impacts. The data tables identify social risks for over 100 indicators. Both the ranking of worker hour intensity and the risk levels across multiple social themes for the Country Specific Sectors (CSS) within a product category supply chain are used to calculate Social Hotspots Indexes (SHI) using an additive weighting method. The CSS with the highest SHI are highlighted as social hotspots within the supply chain of the product in question. This system was tested in seven case studies in 2011. In order to further limit the number of hotspots, a set of prioritization rules was applied. This paper will review the method

implemented to study the social hotspots of the 100 product categories and provide one detailed example. Limitations of the approach and recommended research avenues will be outlined.

Keywords: social life cycle assessment; social footprinting; hotspots assessment; social responsibility; social impacts; supply chain

1. Introduction

Supply chains are increasingly complex and global [1], which entails that additional effort must be invested to learn about the location of production activities included in a product life cycle. It is often difficult for large companies themselves to know where the production sites of their suppliers—even the first tiers of suppliers—are located [2]. Trade models offer a way to estimate where the production activities involved in the product supply chain might be distributed. Location information is paramount for a Social Life Cycle Assessment because of the significant cultural and economic disparities that exist between countries [3–6].

Social Life Cycle Assessment (S-LCA) is a technique for collecting, analyzing and communicating information about the social conditions and impacts associated with production and (in some applications) consumption. Results of an S-LCA can be applied for a variety of contexts including policymaking, company reporting, identifying areas of improvement, allocation of resources, and comparison of the social footprint associated with different products.

As with environmental LCA, it is recommended to begin a study by conducting a hotspot analysis, using generic data to prioritize data gathering [3,7–11]. The term "generic data" is used to refer to data on industry averages, or typical conditions; the counterpart to generic is thus "case-specific." Hotspots are production activities in the product life cycle that provide a higher opportunity to address issues of concern (e.g., human and worker rights, community well-being), as well as highlight potential risks of violations, damage to reputation, or issues that need to be considered when doing business in a specific sector and country [7]. The Social Hotspots Database (SHDB) built by New Earth currently provides social risk information on 22 social themes and including 89 issues characterized for risk. Used in conjunction with a global input/output economic model derived from the Global Trade Analysis Project (GTAP) by New Earth, it offers a way to model product category supply chains by prioritizing hotspots based on worker hours and assessing the potential social impacts that may be significant in particular countries and for specific sectors within that supply chain. Hence, the SHDB offers the information necessary to conduct a generic Social LCA. This system was tested in seven case studies in 2011 [12].

2. Context of the Study

The Sustainability Consortium (TSC) is a membership organization headed by the University of Arkansas and Arizona State University that includes over 100 corporate and civil society organizational affiliates. TSC develops and promotes scientific and integrated tools that foster

informed decision-making for product sustainability throughout the entire product lifecycle across all relevant consumer goods sectors.

In particular, TSC develops Dossiers, which document the potential impacts of a product category, and Category Sustainability Profiles (CSP), which summarize the prioritized hotspots and stakeholder issues. Key Performance Indicators (KPIs) are then developed in a multi-stakeholder fashion for the identified and prioritized hotspots.

TSC employs a variety of strategies to collect hotspot information ranging from expert surveys to literature reviews. The hotspot information collected passes through a "decision tree" which determines when a hotspot is eligible for CSP status.

The Sustainability Consortium contracted the University of New Hampshire and New Earth to apply the SHDB system to generate a list of social hotspots for nearly 100 product categories' supply chains. This assessment focused on products which are imported into the US market. Different markets may import products, components, and commodities from a divergent set of countries listed in Table 1. The SHDB system contains data from GTAP which identifies the main countries of origin and the import shares from each country of origin, for each product category, into each country's market.

Table 1. List of consumer goods assessed.

Food, Bev, and Ag		Paper & Wood	Textile	Electronic	Toy & Others	Home & Personal Care
Wheat	Wine	Toilet Tissue	Cotton Apparel	Computers	Plastic Toys	Laundry Detergent
Oat	Bread	Feminine Hygiene	Cotton Towels	Television	Die Cast Cars	Surface Cleaners
Rice	Cotton	Baby Diapers	Silk	Printers	Other Small	Shower Products
Maize (Corn)	Palm Oil	Home Furniture	Synthetic fabrics	Mobile Devices	Appliances	Personal Cleansers
Packaged Cereal	Salmon	Softwood Lumber	Wool	Display Monitors	Printer Ink	Deodorant
Beef	Coffee	Hardwood Lumber	Rugs	DVDs	Motor Oil	Wet Shaving
Yogurt	Cheese	Copy Paper	Leather	Gaming Systems	Paint	
Butter	Milk	Greeting Cards	Footwear		Batteries	
Berries	Sugar	Paper Towels			Tires (auto)	
Beer	Potatoes	Facial Tissue			Lube (auto)	
Baby Formula	Tea				Petro/ Diesel	
Soybean	Soda				Bicycles	
Beans	Chicken				Light Bulbs	
Potatoes	Pork				Hand Tools	
Sorghum	Turkey				Flatware	
Nuts/Seeds	Eggs				Natural Stone	
Shellfish	Avocadoes				Natural Rubber	
Chocolate	Bananas					
Apples	Citrus					
Cucumbers	Tomatoes					
Leaf Vegetables	Frozen meals					
	Canned Soup					
	Pet Food					

The results from the SHDB assessment were used by TSC as hypotheses that were then tested and verified through additional research (e.g., literature reviews, expert surveys and interviews). SHDB results were also valued in the decision tree process that moves hotspots from the Dossier to the CSP. The SHDB system was applied because it provides an efficient way to identify a first-cut list of prioritized potential social impacts over the entire set of product category supply chains.

In particular, the following elements were motivation for the application of the SHDB:

- It is an integrated data compilation resource that makes it possible to survey and apply a wide range of data sources on relevant issues in a very limited time.
- Its system provides country of origin data for many tiers of the supply chains for which the information is very hard to access otherwise.
- It provides information on labour intensity that helps to prioritize hotspots.
- It provides consistent information for the entire set of product categories under study.
- SHDB data sources and characterization methods are fully transparent.

Literature, especially peer reviewed journal articles, on social impacts of production activities is minimal.

3. The SHDB Method

The SHDB allows users to prioritize production activities and geographies for which additional data collection would shed greater light on the status of social issues. Over 200 reputable sources of statistical data have been used to develop 22 Social Theme Tables by country (227) and economic sector (57). These theme tables make use of 133 indicators, resulting in 89 characterized social issues [12]. A characterized social issue is an impact subcategory for which a level of risk was determined using a characterization model. The indicators included in the SHDB and associated references as well as the characterization methods used to identify levels of risk are provided in a document located on the SHDB website [13].

Data for three criteria are used to inform prioritization: (1) labor intensity in worker hours per country specific sector (e.g., USA-Dairy), (2) risk for, or opportunity to affect, relevant social themes, (3) gravity of a social issue. Labor intensity is determined through the Worker Hours Model, which was developed using a global IO economic model [14] and wage rate data (e.g., ILO LABORSTA [15], UNIDO [16], FAO RIGA [17]).

3.1. Goal and Scope

The goals of the assessment, as originally set forth by TSC, were to assess and prioritize the social hotspots of the product categories, generating a table with the following fields:

- *Supply chain activity stage*: The phase of the life cycle associated with the largest portion of the output from a given Country Specific Sector (raw material extraction, intermediary production, *etc.*);
- *Stakeholder category*: Workers, Local Communities, Society, Value Chain Actors;
- *Impact category*: Human Rights, Labor Rights and Decent Work, Health and Safety, Governance, and Community Infrastructure;
- *Location and sector of concern*: The country (ISO standard) and economic sector [14];

- *Subcategory of impact*: From the list recommended in the UNEP Social LCA Guidelines [7];
- *Specific issue*: The specific indicator(s) compiled in the SHDB.

Since TSC does not have a protocol to incorporate geographical information into its knowledge products, it later opted not to use the location information for production activities which was provided by the assessments. However, our assessment did make use of the (very important) influence of country locations to determine risk levels.

The list of hotspots was determined to include approximately 25–50 lines, detailing the hotspots at the specific issue level and representing 10–15 hotspots (Country Specific Sectors at high or very high risk on some impact categories). In addition to these final result tables, an Excel report documenting every step of the assessment and offering additional perspectives on the findings was produced for each product category.

The functional unit used for the Worker Hour modeling was 1 million US dollars purchased from the product category-associated economic sector. Thus, our results include estimates of the number of work-hours needed or involved in each sector (in each country) in the supply chain, in order to deliver a final output of 1 million dollars of product.

Before launching into the assessments, an automated SHDB Analytica™ model was built. Analytica™ is a program that draws influence diagrams, performs complex computations, and constructs multi-dimensional tables using large quantities of data. This automation helped enable the team to produce lists of results quickly, as required under this project. The implemented assessment process was composed of the four phases illustrated in Figure 1.

Figure 1. Assessment phases.

3.2. Preparation

For each Product Category, the relevant sector from a specified list of 57 was identified first (example: polyester is found in the Textile sector). This list corresponds to the sectors defined by the GTAP economic equilibrium model, which is used for the supply chain modeling and to develop the SHDB Worker Hours Model. After the appropriate sector is identified, one or more (up to eight) primary countries that export the final product to the US are identified (including the US if produced domestically) using sources including the International Trade Centre, the USDA Economic Research Service and Foreign Agriculture Service, and several others. The countries were then each combined with the chosen sector to produce a list of 1–8 Primary Country-Specific Sectors (pCSS) to be tested with the SHDB.

As an example, one of the product categories assessed was rubber tires. The associated GTAP sector is Chemical, Rubber Plastic Products. Using the United Nations International Trade Center's Trade Map, six countries were identified as representing the bulk of the imports to the US market: China, Canada, Japan, Korea, Thailand, and United States [18]. This lead to the identification of six pCSSs to be tested with the SHDB for this product category.

3.3. Modeling

The supply chain modeling and Worker Hours Assessment are performed on all pCSS for each Product Category. For example, for the Product Category *Chicken*, three pCSS were tested: the Meat Products sector in the U.S., Canada, and Chile (Canada and Chile are the two top exporters of chicken to the US). The results of the Worker Hours Assessment are rankings of all CSS in the model (57 sectors in each of 113 countries and regions yields 6441 total CSS) by the share of worker hours necessary to produce 1 million US dollars of the product associated with the specified pCSS.

From the worker hour rankings, all CSS with greater than a 0.1% share of the total worker hours (typically 10–150 CSS met the cut-off of 0.1%) are tested in the Analytica™ model using the SHDB Social Theme Tables. The list of CSS with >0.1% of the supply chain worker hours is input.

Regarding rubber tires, one of the pCSS under assessment were China-Chemical, Rubber, and Plastic Products. The Table 2 below shows an excerpt of the modeling results. The first column represents the CSS sector and country codes. The second column shows the percent share of the total supply chain worker hours associated with the particular CSS. The third column offers the exact number of worker hours associated with a purchase of 1 million US dollars from the primary CSS. In this case, the worker hours are concentrated, with the primary CSS being responsible for over 50% of the total worker hours. Fifty-four total CSS account for 95% of the entire supply chain worker hours. The largest shares of worker hours associated with the pCSS under study are located in China. These 54 CSS were assessed using the Social Theme Tables to identify those with greatest social risks.

Table 2. Example of modeling results: Worker Hours of China Rubber Tire associated sector.

Primary CSS	**Chemical, Rubber, Plastic Products (CRP) CHINA**	**Number of worker hours per 1 million USD**
Total WH/1M USD = 40.811873 Cumulative Share <0.1% = 94.672775% Number of CSS with >0.1% WH = 54		
	Percent of total	
crp–CHN	56.4943%	23.05638884
trd–CHN	4.9533%	2.021534434
coa–CHN	4.6191%	1.885130545
frs–CHN	4.5681%	1.864308119
otp–CHN	2.4725%	1.009080519
ely–CHN	1.8670%	0.761960031

3.4. Assessment

Through a series of calculations that combine weighted risks for social issues within five Social Impact Categories and adjust for the worker hours share, an aggregated Social Hotspot Index (SHI) is determined for each CSS. The SHI was first developed in 2011 by New Earth to prioritize results for seven social scoping assessments [12]. It provides a first cut estimate of potentially significant hotspots.

Each Social Impact Category (*i.e.*, Labor Rights, Health & Safety, Human Rights, Governance and Community) contains a range of specific indicators within multiple Social Themes. Either a single indicator or several related indicators are used to determine the risk of a particular social issue

occurring, which can also be referred to as the opportunity to improve upon a particular social issue. For example, the indicator, Percent of Child Labor, would be characterized as the Risk of Child Labor (or the opportunity to reduce child labor).

Characterization models, which are generally algorithms based on even distributions of the data split into quartiles, are used to assign levels of risk as low, medium, high, and very high. Characterized social issue weights are summed across all social issues per impact category resulting in a total number of weighted hotspot issues. This value is divided by the highest possible risk a CSS could have (if all social issues had very high risk) to calculate the SHI. Issues with no data are discounted in the final weighted sum. The Social Issue Weights that are used are:

0 = low risk or no evidence of risk,
1 = medium risk,
2 = high risk,
3 = very high risk.

This process is repeated for each pCSS. The top 10 CSS with the greatest Social Hotspot Index by Impact Category are carried forward in the assessment. Thus, each pCSS assessment essentially contributes 50 CSS (10 from each of five Social Impact Categories) to the Social Hotspot Prioritization step. For example, the assessment of the pCSS, China—Chemical, Rubber, Plastic sector will generate 50 prioritized CSS, 10 for each of the five impact categories.

In order to increase the hotspot ranking of sectors with a higher share of total worker hours at risk of a given issue, we increased the SHI by a percent share based on the level of labour intensity of the CSS (Table 3). We tested results on the first 10 product categories assessed to calibrate the added share in a way that would still capture very high risk areas further down the supply chain.

The reason behind the additional value placed upon production activities responsible for a higher share of worker hours is two-fold.

First, by definition these represent activities which are responsible for a larger number of worker-hours being at risk for a given issue.

Secondly, it takes into account the recognition that brands and companies may have greater influence on these production activities because they are usually in the second or third tiers of suppliers. However, it is not always the case that the brands have increased influence on these production activities, and the production activities contributing a large share of worker hours can also be further up the supply chains, in the fourth or fifth tiers and beyond.

Table 3. Incorporating the share of worker hours.

Share of the total worker hours per million dollars of product	Weighted sum of social issues percent share increased
≥1%	30%
≥0.2%	20%
≥0.1%	10%

Table 4 provides an example of the results for the Labour Rights Impact Category for the pCSS China—Chemical, Plastics and Rubber sector. China-Coal has the highest SHI for that impact category. This is the result of the combination of weighted risks on all social issues within the Labour

Rights category and the percentage share increase of 30% since the coal sector is responsible for 4.6% of the worker hours associated with the pCSS. In the final spreadsheet, 20 CSS are included for each pCSS and impact categories. However this example shows results for only 10 CSS.

Table 4. Excerpt of the Labor Rights Hotspots Index results table for China—Chemical, Plastics, and Rubber primary CSS.

Labor Rights		
CSS	**WH Share**	**Social Hotspot Index (SHI**
Primary CSS: China—Chemical Products, Plastics, Rubber (CRP)		
China-Coal	4.6191%	173.8095238
China-Chemical, rubber, plastic products (CRP)	56.4943%	166.6666667
China-Commerce	4.9533%	152.3809524
China-Forestry	4.5681%	145.2380952
China-Transport nec	2.4725%	145.2380952
China-Machinery and equipment nec	1.3074%	125
China-Paper products, publishing	1.0461%	119.6428571
China-Electricity	1.8670%	114.2857143
China-Financial services nec	1.6003%	108.9285714
China-Minerals nec	1.5693%	108.9285714

3.5. Prioritization

Even with some initial prioritization conducted using the SHI, there are still 50–100 potential hotspots identified for each pCSS (with some overlap). In order to further prioritize, a first set of potential hotspots is selected based on the following rules. The CSS is chosen if it:

- Is one of the pCSS;
- Has the highest SHI in a Social Impact Category (the SHI also values WH share);
- Appears in four out of five Social Impact Categories for a pCSS;
- Shows up in a single Social Impact Category but for a large share of the pCSS (countries) relevant for the product category, where "large share" is defined as *all* when the number of pCSS is two or three, and *all-but-one* when the number of pCSS is four or more.

Carrying forward this abridged list of potential hotspots, a final list of CSS is selected. If a CSS is ranked in the top 3 (according to the SHI rankings) in any Social Impact Category, it is selected as a hotspot. If it is not ranked in the top 3, the highest ranked CSS in one Social Impact Category is chosen. From this near final list, a spot check is performed.

CSS are removed if it is a service sector from a non-pCSS country or does not clearly relate to the product's supply chain.

This step requires further web research in order to confirm the importance of the identified hotspots to the product category under study.

Web research may be straightforward and quick or long and challenging depending of the availability of information for the product category under assessment.

From this assessment, a Social Hotspot Table based on the SHDB is prepared to serve as a starting point for the incorporation of the information to TSC Dossiers (an abbreviated example is shown in Table 5).

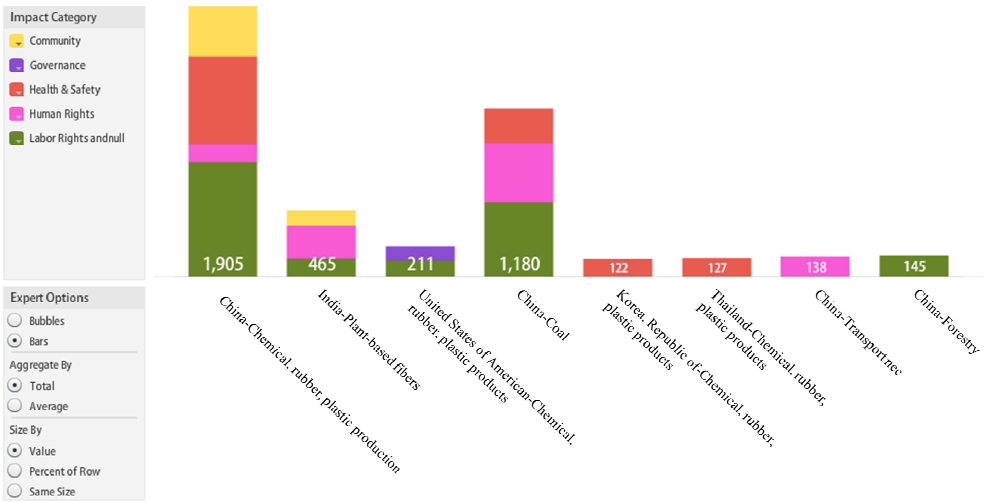
The Dossier contains not only the CSS chosen as hotspots, but also the life cycle activity phase for the CSS (not shown here), the social issues with very high (and sometimes high) risk within the Social Categories for each chosen CSS, and references (not shown here) for the SHDB inventory data from which that risk was determined.

Table 5. Final result table excerpt for tire SHDB assessment CRP: Chemical Products, Plastics, Rubber (CRP).

Stakeholder category	Impact category	Location and sector of concern	Subcategory of impact	Specific issue
Local Community	Human Rights	China-Coal	Respect of Indigenous Rights	Risk that indigenous people are negatively impacted at sector level
Workers	Working Conditions	China-CRP	Working Hours	Risk of excessive working time by sector
Workers	Health and Safety	Thailand-Chemical, rubber, plastic products	Health and Safety	Risk of fatal injury by sector
Workers	Working Conditions	China-CRP	Forced Labor	Risk of Forced Labor by Sector
Workers	Working Conditions	China-Coal	Forced Labor	Risk of Forced Labor by Sector
Workers	Health and Safety	Korea, Republic of-CRP	Health and Safety	Risk of loss of life by airborne particulates in occupation

Finally, in order to offer a visually appealing analysis and representation of the results, graphs were developed. For the top eight CSS identified as hotspots for rubber tires, Figure 2 displays SHI by Impact Category as a result of considerable social issue risks and worker hour contribution.

Figure 2. Combined Social Hotspot Indexes for Chosen Hotspots in Rubber Tire Supply Chain (color shows impact category).



4. Conclusions

Determining the most pressing and significant areas for improvement in product supply chains is a daunting task. Supply chains are complex, hotspots are numerous and different stakeholders have different values and priorities. There are four crucial elements contributed by the SHDB that enhance social hotspot analysis and can inform decision making: (1) the modeling of the entire supply chains by Country Specific Sector, (2) the estimate of worker hour participation associated with each activity in the supply chain, (3) a coherent, self-consistent and transparent information system, (4) a flexible set of transparent risk characterization models. Each of these elements can help support development of answers to the question at hand, which in our case was one of allocating resources or measuring progress. The methods implemented here are one possible approach for making better decisions, making use of the data provided by the SHDB system. Different calculations of a Social Hotspots Index (SHI) can be developed and implemented to provide alternative perspectives. Other tools such as multi-criteria decision analysis can be deployed in developing other versions of an SHI and the rules may be modified to account for additional factors.

The SHDB assessments prioritize results on three main accounts: (1) gravity of the issue, (2) severity of the risk level, (3) and labour intensity. Results are also calculated to take into account overlaps in between supply chains of pCSS. Other factors may also intervene in the decision-making process such as the sphere of influence, presence of regulations, stakeholder pressure and the availability of practical means (such as traceability technology). The main limitation of the approach stems from the lack of sector granularity in the GTAP model and the lack of sector-specific data for some indicators. Improvements are underway as we update and expand the data within the SHDB system and pursue linkage of the risk data with process-based LCI inventory databases. At the same time, complementing the SHDB assessment with other sources of information also helps to alleviate some of these limitations.

Years of research have shown that the best way to promote improvement of social impacts in supply chains is to engage with suppliers, local communities, workers, governments and NGOs [19,20]. SHDB assessments help to visualize an initial snapshot of the hotspots associated with a product category supply chain and may support reporting. They are at the same time just the start of a much larger process of initiating change in the social sphere that is greatly affected by production and consumption of products.

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Author Contributions

Catherine Benoit Norris conceived the project methodology. All authors contributed to conceive the assessments methods. All authors contributed to the development of the Social Hotspots Database. Deana Aulisio performed the assessments. Catherine Benoit Norris and Deana Aulisio analyzed the

data and compiled the results. Catherine Benoit Norris and Gregory A. Norris wrote the paper. All authors have read and approved the final manuscript.

Conflicts of Interest

This article was preliminary presented at CILCA 2013—V International Conference on Life Cycle Assessment in Latin-America. The authors declare no conflict of interest.

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