Leveraging Data for Increased Sustainability of Products & Factories

by

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B.S. Civil Engineering, University of Colorado at Boulder, 2010

Submitted to the MIT Sloan School of Management and the Department of Civil and Environmental Engineering in partial Fulfillment of the Requirements for the Degrees of

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ABSTRACT

Li & Fung is a supply chain leader in consumer goods specializing in apparel, beauty products, furnishings, household goods, health and toys. It employees more than 20,000 people and supplies material from 15,000 suppliers in more than 40 countries. Managing the environmental impact of products made by Li & Fung and its suppliers is a crucial part of LF's sustainability strategy.

The objective of this internship based project is to assess product environmental footprint throughout multiple tiers of the garment supply chain. The approach to resolve the problem is to investigate of the current state of Li & Fung factories, create a mobile tool to collect and analyze data from factories and produce final environmental scores for factories and products.

The mobile tool and the environmental scores will allow (1) factories to benchmark against each other in terms of their environmental performance, and (2) provide essential data to brands (Li & Fung customers) to make more conscious sourcing decisions.

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Lastly, I thank my LGO classmates. If I had to pick a favorite take away out of the program, it would be making 44 new friends. I've enjoyed interacting with the LGO class inside and outside the classroom and I am overjoyed to have 44 friends for life.

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GLOSSARY OF TERMS

EPA United States Government Environmental Protection Agency

FG Fung Group: a collection of companies including LF.

FOB Freight On Board, used in this document to refer to the price the manufacturer charges the buyer for a piece of garment

LCA Life-Cycle Analysis: a method used to measure the environmental impact of a product throughout its lifecycle.

LET Li & Fung Environmental Tool

LF Li & Fung Limited: host of the internship projects, world supply chain leader in consumer goods.

LGO Leaders for Global Operations

SAC The Sustainability Apparel Coalition: a sustainability nonprofit organization established by collection of fashion companies, non-profit agencies and the EPA

SEHK The Stock Exchange of Hong Kong Limited

WRI World Resources Institute: independent research organization focusing on sustainable natural resource management

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CHAPTER 1: INTRODUCTION

1.1 Problem Statement

Li & Fung (will be referred to as LF from this point onwards) considers sustainability to be an "integral" part of its business. The company states its sustainability strategy as follows:

> *We responsibly manage our own environmental, social and governance performance. We work with our customers, suppliers and industry partners to further the sustainability of supply chains and communities across our network. We assess our progress against our sustainability goals, set aspirational targets against best practice benchmarks and take action to meet those targets. Our strategy is comprised of the following four pillars [1].*

Managing the environmental impact of products, made by LF or its suppliers, is a crucial part of LF's sustainability strategy. LF conducts extensive environmental campaigns and trains suppliers on improving their energy efficiencies. Moreover, a number of LF facilities are LEED certified. As part of LF's environmental commitment, it launched this internship project with the objective of studying and (eventually) mitigating the environmental impact from garment products and factories.

1.2 Hypothesis and Project Motivation

The main assumption in this project is that there are four main environmental dimensions that are behind evaluating factory and product environmental performance. The four dimensions are: fabric waste, electricity[1], water and wastewater. Eventually, other dimensions such as chemicals and CO2 emission will be studied as well. Using the four mentioned dimensions was motivated by way the French sporting goods company 'Decathlon' handles its product sustainability. Decathlon launched an initiative

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[1] Electricity and energy are used interchangeably in this document. Specific differences are stated with units in section 5

to calculate and display the environmental performance of its products in stores. Decathlon's environmental label was based on similar four environmental dimensions.

1.3 Thesis Overview

Chapter 1 provides a brief explanation of the problem statement, hypothesis and project motivation. **Chapter 2** gives company and industry context and their environmental impacts. **Chapter 3** discusses the literature behind the four environmental dimensions used in the analysis of this thesis. **Chapter 4** details the quantitative approach of the internship project including data collection, data integration and environmental score calculations. **Chapter 5** analyzes the data gathered for both factories and products and provides results **Chapter 6** provides conclusions and recommendations given based on factory and product scores to enhance their environmental performances.

CHAPTER 2: COMPANY AND PROBLEM BACKGROUND

2.1 Li & Fung

LF is a supply chain leader in consumer goods specializing in Apparel, beauty products, furnishings, household goods, health products and toys. It employees more than 20,000 people and supplies material from 15,000 factories in more than 40 countries (see Figure 1 for LF's global reach). It's a public company listed in The Stock Exchange of Hong Kong Limited (SEHK). LF is the trading and logistics arm of the Fung Group (FG). The FG itself includes other corporations in distribution and retailing. Refer to Figure 2 for group structure [3].

LF started as a family business in 1906 in what is known today as Guangzhou in China. Fung Pak-liu and Li To-ming (hence the name Li & Fung) began trading jade, porcelain, handicrafts, antiques and fireworks until 1949 when China became communist. The business was bought by the Fung side and moved to Hong Kong under the leadership of and Fung Pak-liu's son, Hon-chu. Hon-chu's sons (William and Victor) then modernized the business and listed it in SEHK. Currently William is the FG Managing Director and Victor is the honorary Chairman of LF and the chairman of the FG.

Figure 1: LF's global network. Source: company presentation.

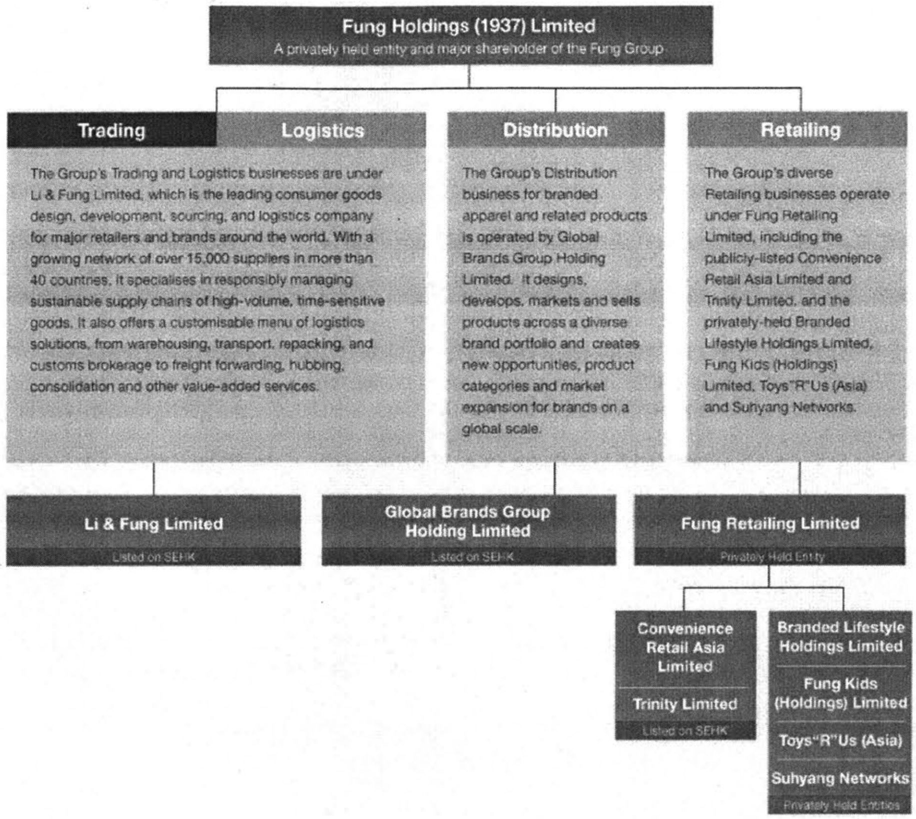

Figure 2: Fung Group structure

2.2 Apparel Supply Chain

Apparel (or garment) manufacturing is a complex process. A huge combination suppliers, farmers, manufactures and fabric mills might be used to produce a single piece of garments. Let's take the process of producing a cotton t-shirt as an example, see Figure 3 for a simplified flowchart of garment manufacturing [4].

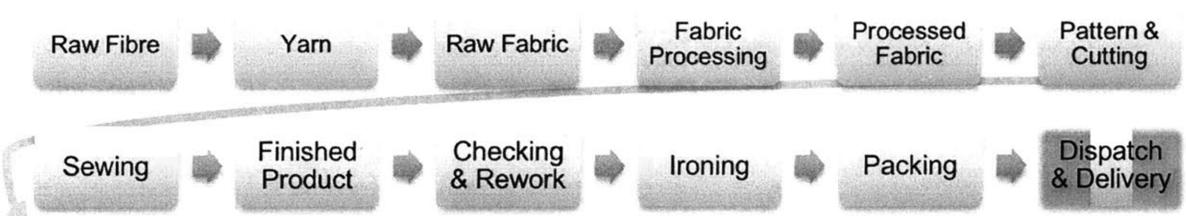

Figure 3: flowchart of garment manufacturing

Cotton (whether conventional or organic) is grown in cotton farms. The world's five leading countries in cotton farming are (in descending order) India, China, the United States, Pakistan and Brazil [5]. Cotton is harvested, compacted and then sent to ginning factories where they are cleaned and separated from cotton seeds to become 'lint.' The clean lint is then baled (bundled) and stored as inventory. Baled cotton can stay up to 2 years before it starts degrading. The baled lint is sent to fabric mills.

In the mill, the lint goes through a series of processes including sucking, carding, drawing, combing and roving. It is then spun over and over until it turns into the soft cotton we know. To turn it into fabric, the cotton is spooled into thread then it is woven (or knitted) into fabric. After the woven (or knitted) fabric has been processed, it is sent to dyeing. After dyeing, the fabric is dried, rolled neatly and sent to garment factories.

In the garment factory, fabric is checked for quality and consistency. Dyeing is done to get the right color (mostly for Denim products). A cutting pattern (layout of cutting) is decided by a computer software (Figure 5). Fabric is laid by laying machines (or manually) and then it is cut as per the cutting pattern. Cut pieces are sewed together through a carefully planned sewing line. The final product is cleaned, ironed, checked and packaged before being sent to the customer.

2.3 Apparel Environmental Impact

Apparel manufacturing throughout its long supply chain uses an enormous magnitude of resources, accounts for a significant amount of the world's CO2 emissions and discharges millions of gallons of wastewater full of harmful materials.

Apparel manufacturing relies on heavy consumption of energy. Every major process whether it's raw material harvesting, fabric processing, cutting and sewing, dyeing, ironing, packaging or delivery uses lots of energy and therefore, emits plenty of baleful gasses into the atmosphere. In fact, the apparel industry is responsible of 10% of CO2 emissions in the world. This makes the apparel industry the 2nd most air polluting industry after oil and gas [6].

It takes 2700 liters (over 700 gallons) to produce the cotton used in a single 100% cotton t-shirt [7]. That is enough to fill a bathtub more than 20 times! This large consumption of freshwater comes at the expense of a world that is more vulnerable than ever to water scarcity issues. The United Nations estimates that two-thirds of world nations will face water scarcity by 2025 [8]. The World Resources Institute demonstrated water stress level in the world in a heat map, Figure 4 [9].

The picture is no less grim when it comes to wastewater. 25% of the chemicals produced in the world are used in textile. Dangerous pesticides in farming, conventional bleaching in textile mills and water-based dyeing processes in garment production all contribute to millions of gallons of wastewater discharged every year. Moreover, Plastic microfibers from synthetic clothing represents about 85% of the man-made material that is left along ocean shores. Such fibers endanger both marine life and the food supply chain [6].

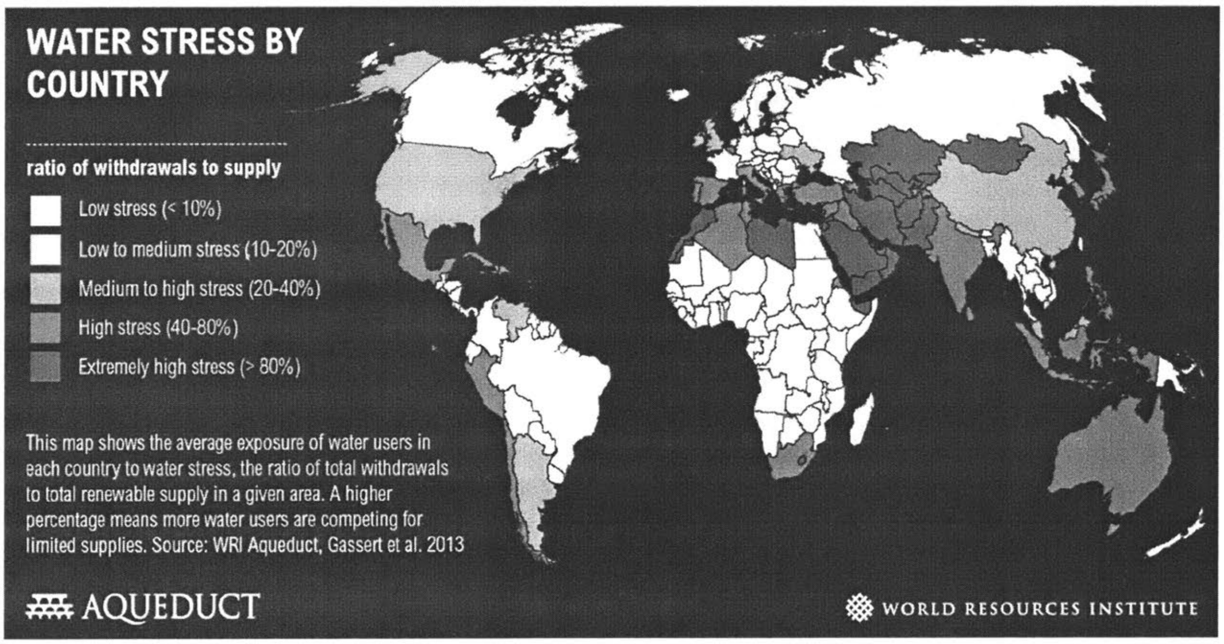

Figure 4: Water Stress Level heat map provided by The World Resources Center

Finally, fabric waste is another dimension of the environmental impact of the garment industry. Manufacturers never fully utilize all the fabric in hand. Extra materials and defected parts usually end up in landfills (rarely recycled or reused). Fast fashion, in particular is a huge contributor to the fabric waste issue with faster trends and lower-quality cloths. It is estimated that the average Americans discards 70 pounds of cloths a year while a single piece of fast-fashion garment is worn about five times only [6]

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

This chapter introduces the different dimensions used to produce both a factory-level and a product-level environmental data. The dimensions used are fabric waste, electricity, water and wastewater efficiency. As mentioned before, those dimensions were inspired by Decathlon's environmental label. But there are other reasons why such dimensions were picked.

First, the dimensions were relatively easy to collect data on from factories. For example, it's much more difficult to ask factories about the chemical composition of their bleaching or dyeing processes than it is to simply ask them about how much wastewater they produce and how of much it is recycled.

Second, those dimensions allow for scalability of the study of factories and products. Every factory uses electricity and water the same way that every factory gets rid of excess material and wastewater. This allows for a fair comparison between different factories and products.

Finally, those dimensions were the easiest for customers (brands) and final consumers to associate with. In the results section, it's demonstrated that customers and consumers can see that for a certain product, the electricity needed to produce a product in equivalent to lighting a bulb for an hour.

3.2 Material Efficiency

Material efficiency is defined here by the amount of used fabric divided by the amount of the purchased fabric. During garment manufacturing, and before cutting takes place, a computer-aided marker is used to generate an optimized cutting pattern. The cutting pattern is a layout of how the fabric is going to be cut into smaller pieces which will later be sewed together to make the complete piece of garment.

Higher sophistication in the computer software, type of fabric and pattern development can all influence the material efficiency. See Figure 5 for an example layout of pattern making [10]. Pattern making software help maximize the percentage of used material and reduce fabric waste by reorient parts.

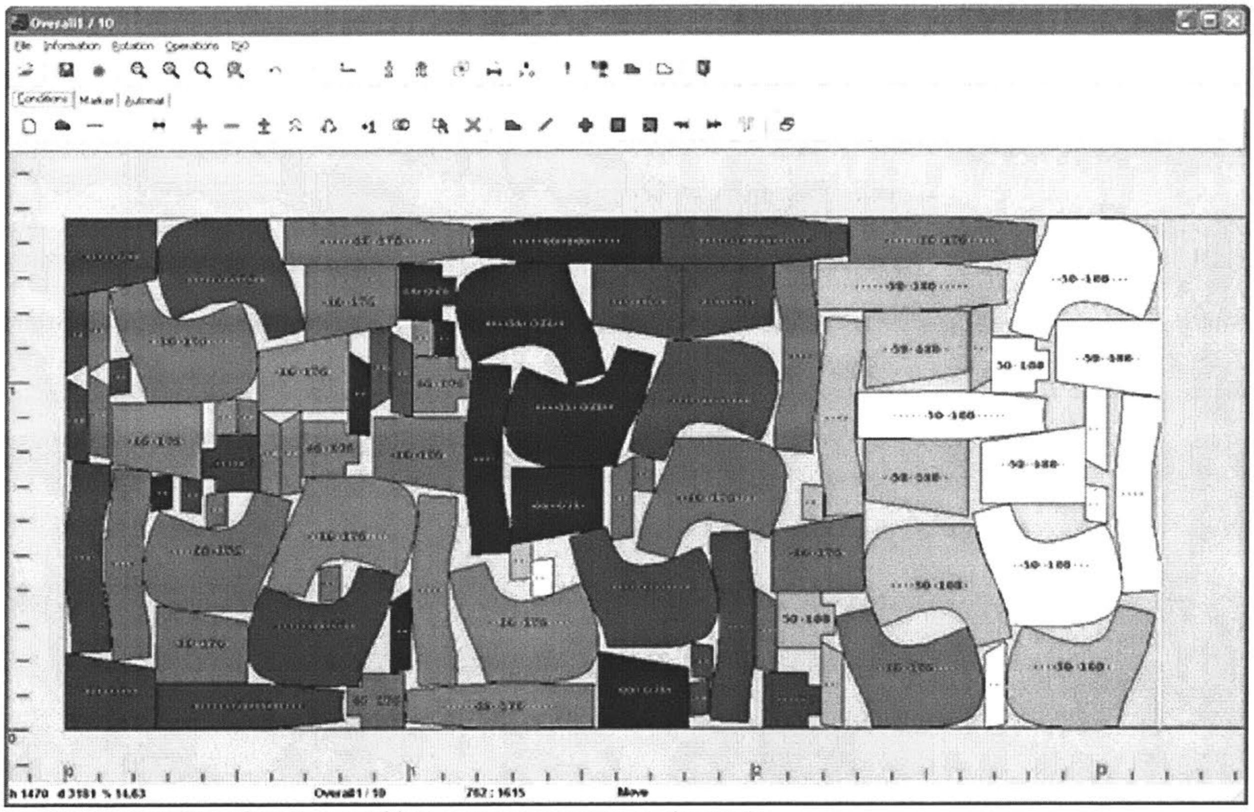

Figure 5: example of pattern making, grey area represents waste.

3.3 Energy Efficiency

Energy consumption in the garment industry varies depending on the final product. Making a simple cotton shirt requires much less energy than making a pair of jeans. This is mainly due to the extra steps a pair of jeans has to go through such as multiple cycles of washing (to get the right color) and drying. On the other hand, even in making the same type of product, factories approach energy consumption differently. New factories and factories of high-end products tend to have efficient lighting, heating and cooling systems. They install the latest models of sewing, washing and drying machines. They use automated processes that with built-in sleep mode when the machines are not in use. On the other hand, old factories and factories of lower-end products tend to lack LED lighting fixtures and have old machinery that consumes large amounts of electricity.

Despite the fact that there might be a clear correlation between how modern a factory is and its energy, sometimes the location of the factory plays a huge role in determining the consumed electricity. In a visit to factories in Bangalore in India, we noticed that the temperature rarely varied during the day. Factories barely needed ceiling fans to keep the temperature in a pleasant level inside the factory. On the other hand, factories in Phnom Penh in Cambodia had to use air conditioning (especially in administration areas) and cooling fans as temperatures average between 30 and 35 degrees Celsius (85 to 95 Fahrenheit).

3.4 Water Efficiency

In determining water efficiency two main factors are considered in this study: water usage and water scarcity. Water scarcity data is obtained from the region or country where the sourced material is as well as where garment factory is located. Water consumption is a key component of garment manufacturing. There are processes that are a few processes that heavily depends on water such as fabric washing and wet dyeing of fabric. Water efficiency is especially important in regions where water scarcity is an issue. A factory in Bangladesh that consumes the same amount of water as a factory in a dry region in India is still considered more water efficient. This is due to the plentiful sources of fresh water in Bangladesh and scarcity of water in some regions of India (relative to Bangladesh).

3.5 Wastewater Efficiency

Two metrics have been used to measure wastewater efficiency: the amount of discharged wastewater and the amount of recycled wastewater due to in-house or outsourced water treatment. The composition of wastewater including the different chemicals has not been measured and therefore, is not part of the calculations.

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CHAPTER 4: METHODOLOGY

4.1 Introduction

The methodology used to arrive at the environmental scores consists of the following: investigation of the current state of LF factories, gathering secondary data, creating an online mobile tool (see **Exhibit 1** for screenshots of the mobile tool) for primary data collection and environmental score calculations.

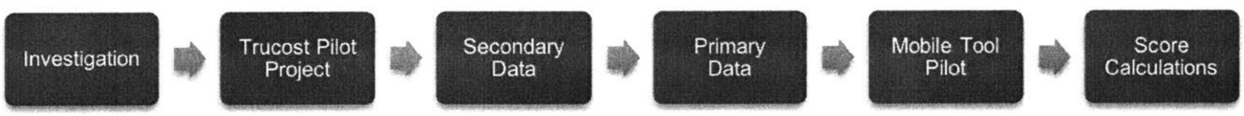

Figure 6: process flow of project

4.2 Investigation

The investigation phase started with visits to LF garment factories in different countries including China, India, Vietnam and Cambodia. Visits to those factories took place for two main reasons. First, visiting factories provides insight over the manufacturing process of garments. Second, it makes one understand how much factories are really familiar with the environmental impact of their products. The second reason is particularly important because it helps identify which questions factories can actually answer about their facility's environmental impact and which questions might be too difficult to ask for.

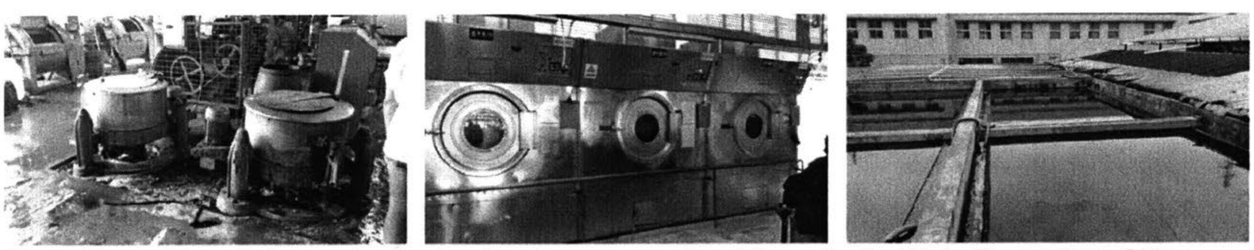

Figure 7: washing, drying and water treatment processes in a LF vendor facility in Zhongshan, China

4.3 Pilot Project

In order to learn from industry experts, LF hired a third-party company specializing in environmental studies. The company is called Trucost and it is a world leader in sustainability research.

Trucost developed environmental footprinting for two LF products, a cotton t-shirt and a wool sweater, using published life cycle inventory data and scientific studies of textile production. The pilot study relied on five indicators: climate change, land and water pollution, water depletion, land occupation and air pollution. Data was gathered from factories using a vendor questionnaire and included questions on production activities, value chain participation, energy and resource consumption, and pollutant emissions. Data was then expressed in quantities of emissions or resource consumption, and as monetary values representing the social cost of these environmental impacts [11]. There were many lessons learned from the Trucost study that were implemented in this project, especially when creating the environmental mobile tool.

4.4 Secondary Data

Environmental initiatives in the garment industry are still in development. The Sustainable Apparel Coalition (SAC) was established in 2011. The Higg Index was announced in 2012. Therefore, there exists very little data on the environmental performance of factories and products with the exception of specific life-cycle analyses (LCAs).

Despite lack of already-available data (secondary data) about the environmental impact of the garment industry, there exists data that is still relevant. Example of such data include water scarcity data and material-level footprint. Such data is collected and either added as part of the final environmental scores or used to verify primary data.

4.5 Primary Data (mobile tool)

The current method of studying environmental impact of garment factories has been established by a previous Leaders for Global Operations (LGO) intern. The method is called the "Li & Fung Environmental Scorecard". The method consists of sending a questionnaire in a spreadsheet format to factories asking them about their air emissions, water consumption, chemicals, wastewater and solid waste. The questionnaire was followed by an on-site visit to the factory to verify factory's input and to help factories complete the questionnaire. The visit usually took about half a day, excluding travel and local transportation.

While the environmental scorecard provided detailed measure to environmental performance, it lacked the following:

Scalability: The environmental scorecard was piloted in about a dozen factories and required more than a week-long worth of travel of the LGO intern. The LGO intern needed to be accompanied by company personnel for logistics and translation.

Autonomy: The scorecard needed a person with environmental expertise (or at least sufficient environmental awareness) to visit factories and assess their input on the spreadsheet.

Despite the Scorecard's lack of scalability and autonomy, it did provide a new way to measure the environmental impact of factories without the complexities of the Higgs.

While visiting garment factories in South-East Asia, it was noticeable that almost everyone in the production floor had a smartphone. Tablets as well replaced computers as data-entry devices. Smartphones and tablets have become the not only the future but the present of digital interaction. Figure 8 demonstrates the rise of smartphones and tablets during this decade [12] [13]. Therefore, it was decided to take advantage of smartphone technology in this project.

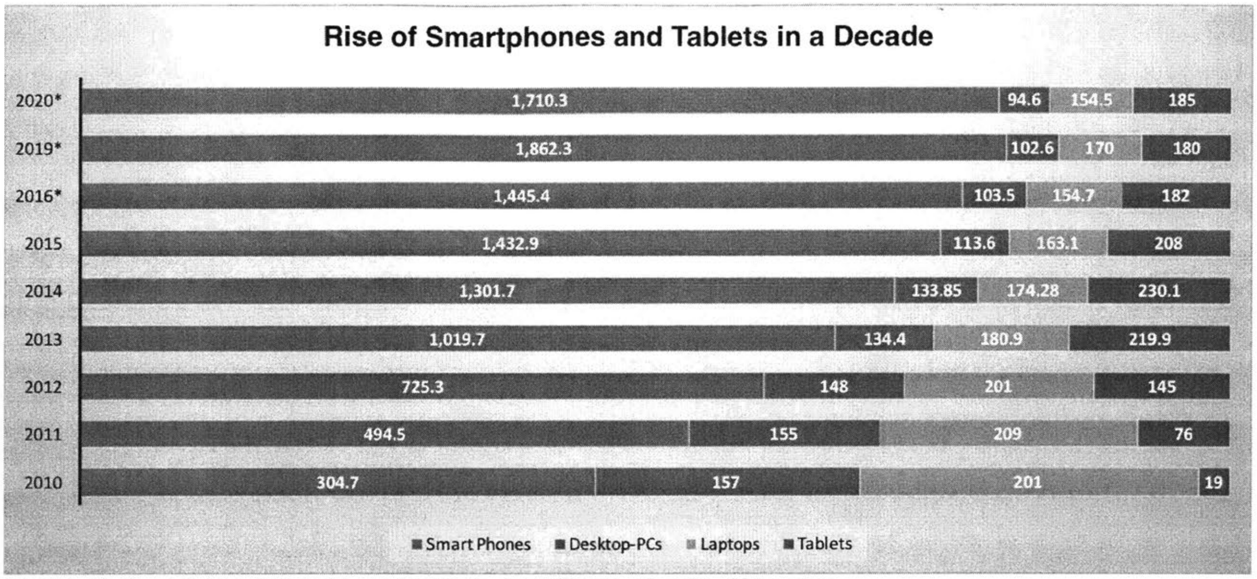

*Figure 8: rise of smartphones and tablets, in millions of units, *forecast*

An online mobile tool called LET (LF Environmental Tool) was established with the goal of collecting and consolidating environmental data from factories. The mobile tool was built on an online platform called Form Stack which specializes in hosting tools developed by users to obtain and store data.

The way LET works is that a link or QR code is sent to the end-user (factories). The end-user answers the questions and upload the necessary documents using the tool itself without having to interact with the creator (LF). Questions and documents in the tool include the following:

- **Basic Information:** name, email and job title of tool user.
- **Factory Information:** name, address, factory total floor area, # of permanent and contract workers, product category (Woven, knit, jeans), factory processes (cut/saw, laundry, ironing, dyeing… etc).
- **Product Information:** type (t-shirt, shorts, …), weight, annual FOB of factory, annual FOB of one piece of this product, % of waste material, country of sourced material.
- **Electricity information:** electric bill in last 3 months (whole facility), natural gas bill for last 3 months.

- **Water Information:** water bill in past 3 months (whole facility).
- **Wastewater Information:** wastewater generated in past 3 months (whole facility), wastewater reused in past 3 months (whole facility).

The tool had many features that distinguished it from traditional data collection methods (see Figure 9 and Figure 10 for illustrations of features):

No Middleman: LET contains a limited list of impactful and concise questions. This allowed factories to answer all the questions without having to go back to LF every single time. It also removed the necessity to have LF employees on the ground saving the company plenty of time and money that would have been spent on travel. Previous methods required about 1 day for factory visit and travel.

Doc. Upload: The tool asks factories to upload copies of electricity and water bill as well as an illustration of the piece of garment. This can be done by using the camera functionality within the smartphone. No need to scan and email copies anymore.

Digital Format: Using LET makes data already available in a digital format so it can be shared, integrated with other data sets and analyzed easily.

Authentication: Even without having employees physically present at the factories, the LET has many verification methods that helps authenticate the input data:

- The user is asked to upload the official documents regarding electricity and water bills. These documents can be compared to the raw numbers in the tool.

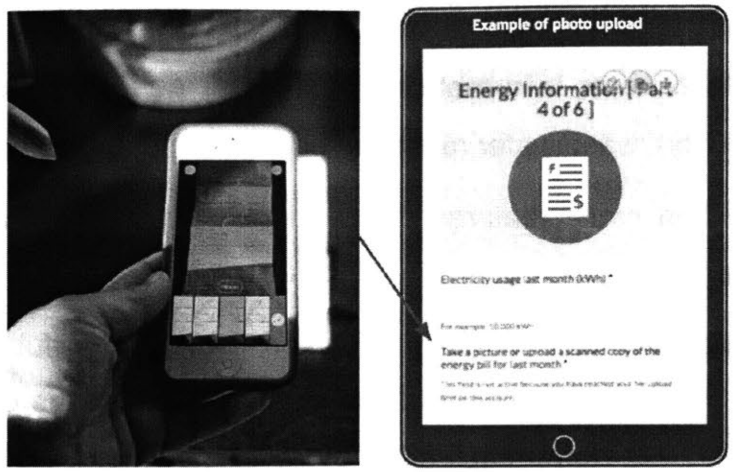

Figure 9: illustration of how document upload works in the tool

- From the IP address where the user is logged into, GPS coordinates are auto-generated within the tool. This verifies that the person who's answering the questions in the tool is indeed doing so within the factory premises.

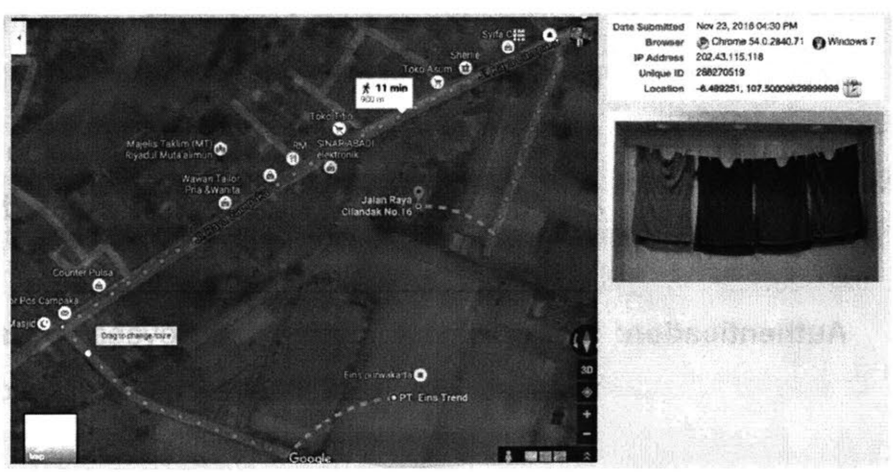

Figure 10: Location feature - top-right corner is location data of the factory along with samples of the studied product. The map on the left shows the highlighted premises of the factories and the location (red drop pin) given by the tool.

LET was sent to over 40 factories in several countries, see Figure 11. A follow-up visit to some of these factories was done to gather feedback from factories and remove some of the glitches in programming the tool. Factories overall, found the tool very user-friendly and were able to complete the questionnaire in the tool including taking photos and scanning documents in a couple of hours. The normal environmental audit takes 1-5 days to complete.

Figure 11: countries where the tool was tested

4.6 Environmental Score Calculations

The tool aggregates all collected data into one spreadsheet. Analysis on the data was done on the first 30 responses (the total responses were over 40 but came later). Table 1 shows a list of the major inputs used to arrive at the final environmental scores. More details on the results are found in section 5.

Factory floor area in m^2	# of permanent factory workers:	# of contract factory workers:	Product categories produced	Factory processes
Product type	Product weight	Total FOB of the facility this year	FOB of this product	Percent of wasted material
What do you do with waste fabric?	Material type 1	% of material 1 used	Countries of sourced fabric	Countries of raw materials
Total Electricity for last 3 months	Total Natural gas for last 3 months	Monthly amount of wastewater	Monthly amount of reused wastewater	Monthly amount of wastewater

Table 1: list of major input field

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CHAPTER 5: DATA ANALYSIS

5.1 Garment Factory Environmental Performance

In this section, the environmental impact of only garment manufacturing is studied. Upstream supply chain tiers were not studied in this project due to the difficulty of accessing upstream suppliers. However, future project will build over this project and will include upstream layers.

Factory environmental performance was divided into the following categories: material efficiency, energy efficiency, water efficiency and wastewater efficiency. An overall analysis of the studied LF factories on these categories is as follows:

I. Material Efficiency

The amount fabric waste for the studied factories ranged from 1 to 40% depending on the country, fabric and factory practices. The average fabric waste was 9.9%. 60% of the fabric was either reused or collected by a third party. In Cambodia, however, about 75% of studied factories received payments from a third party to collect the factories' extra fabric. This practice was not as common in factories in studied factories in China, India, Indonesia or Vietnam.

Figure 12: methods of collecting waste

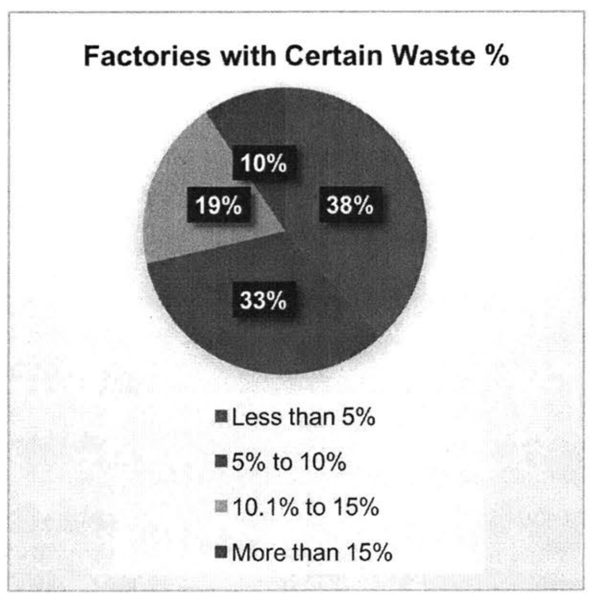

Figure 13: percent of collected waste

II. Energy Efficiency

Energy usage varies depending on the involvement of energy-consuming machinery in the production process. Simple cut-and-sew factories in the studied countries consumed less energy than factories that contained washing, drying and wastewater processes.

Note: not enough energy data on Bangladesh factories.

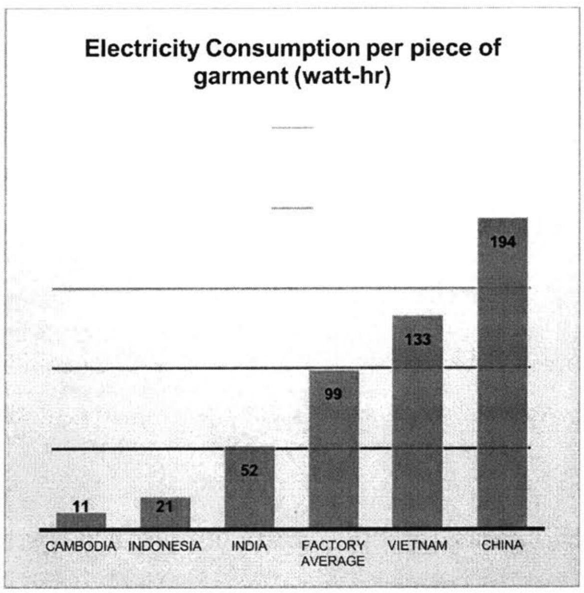

Figure 14: factory electricity consumption[2]

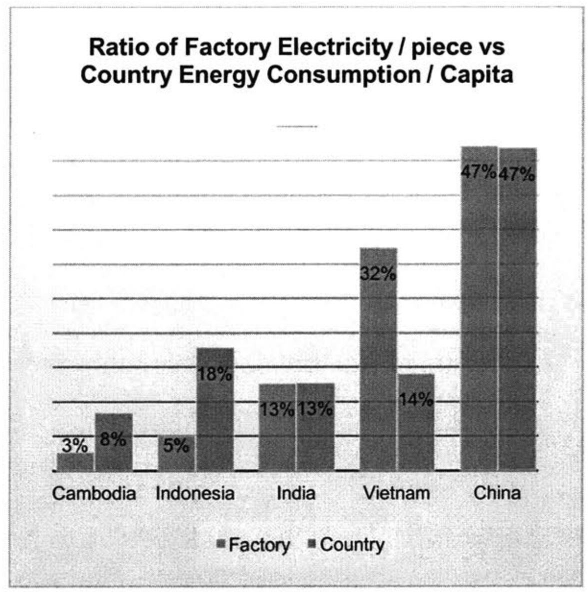

Figure 15: factory vs country electricity consumption

The average energy needed for every dollar made of material is about 100 watt-hours, which is enough to power a lightbulb for an hour (Figure 14). Factory Electricity figures are consistence with overall country consumption (Figure 15) [14] in China and India. The largest disparities where in Indonesia and Vietnam. The data tells us that Indonesia's factory consumption is fairly low while Vietnam is much higher. This is wither due to higher efficiencies in Indonesia or more complex

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[2] Electricity consumption per piece means the amount of watt-hour consumed per product. For example, factory that makes a $5 t-shirt, consumes 20 million kWh per year and produces $10 million worth of goods would have an electrical efficiency of

$$20 * 10^6 watts.hrs * \frac{\$5}{\$10^7} = \mathbf{10\ watts - hour\ per\ piece}$$

process in Vietnam or a combination of both. This can be confirmed as more data is gathered from LF factories in future studies (possibly using this tool as well).

III. Water and wastewater Efficiency

43% of studied factories use a process that involves water consumption. The average used water is about 8000 m^3 per factory per year. About a quarter of factories with water-based processes reuse some of their water. The average reused water amongst factories that recycle is about 28%.

On Average, 459 ml of water is used in cut-and-sew factories to make a single piece of garment, 340 ml of water are wasted (wastewater) and 95 ml is recovered through water treatment for every dollar of garment made. In comparison with the earlier statistic about 700 gallons of water to make a single t-shirt, most of the used water comes during the planting and growth of cotton. The production step contributes very little to water usage (about 5-10 %).

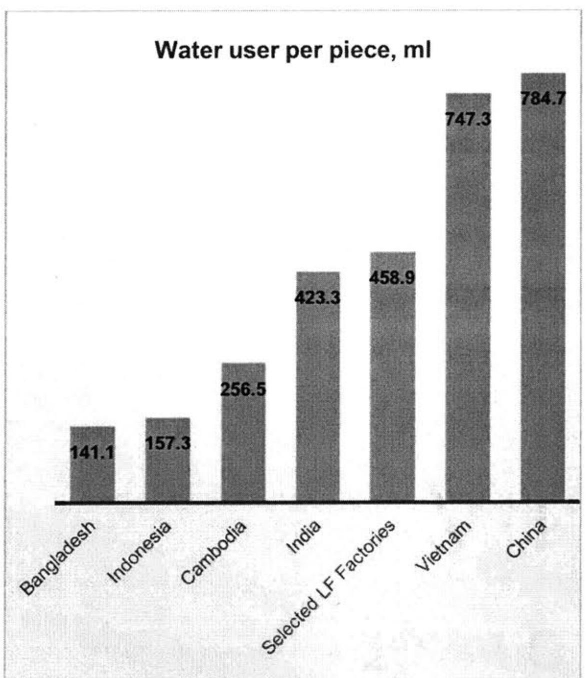

Figure 16: water use per dollar value

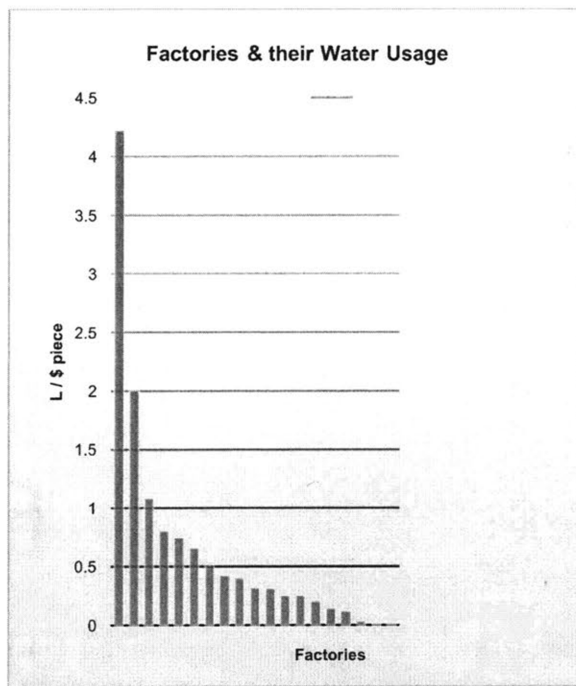

Figure 17: factory distribution per water use

5.2 Factory Case Study

As mentioned before, one of the reasons for creating this tool is to give feedback to the factories. In this section, a case study is presented on one of the garments factories and we will call it Factory X.

The factory is in Cambodia's capital, Phnom Penh. It has a total floor area of over 20,000 m^2 (5 acres) and employs around 1,300 employees, most of which are contract workers. The factory floor includes 22 lines x 32 employees per line. The facility has no water treatment neither does it reuse its water.

It produces 6 million pieces of fashion knits a year. For this project, women's denim pants and shorts for major American retailers were studied. The factory imports the vast majority of its fabric from China.

The score methodology is based on the collected sample only and isn't compared to country or global averages. As this tool gets more scaled up to more LF factories, scores will become more relevant. The score metric is as follows

For Wastewater

A	$S > \mu + 0.5\sigma$
B	$\mu + 0.5\sigma \geq S > \mu + 0.25\,\sigma$
C	$\mu + 0.25\,\sigma \geq S \geq \mu - 0.25\,\sigma$
D	$\mu - 0.25\,\sigma \geq S \geq \mu - 0.5\sigma$
F	$\mu - 0.5\sigma > S$

Table 2: factory score metric for wastewater

For all other dimensions

A	$\mu - 0.5\sigma > S$
B	$\mu - 0.25\,\sigma \geq S \geq \mu - 0.5\sigma$
C	$\mu + 0.25\,\sigma \geq S \geq \mu - 0.25\,\sigma$
D	$\mu + 0.5\sigma \geq S > \mu + 0.25\,\sigma$
F	$S > \mu + 0.5\sigma$

Table 3: factory score metric for all other dimensions

S: factory's measure in waste, electric, water or wastewater dimension

μ: average measure for all factories

σ: standard deviation of the measure for all factories.

Score for factory X:

Dimension	*Description*	μ	σ	S	*score*
Material Efficiency	% excess material	9.9	11.0	10.0	C
Energy Efficiency	Watt-hours / $	99.3	281	127	C
Water Efficiency	Milliliter / $	459	486	202	B
Wastewater Efficiency	% reused water	11.4	28.4	0	D
Overall Score					**C**

Table 4: factory X score

With such score, factory management can prioritize initiatives to improve their environmental performance. As the previous example illustrates, wastewater Efficiency is an area where the factory scored the least when benchmarks to other Li & Fung factories.

5.3 Product Full-Life Environmental Impact Case Study

The environmental performance of garment products is of great interest to brands that are customers to both factories and LF. This section will present analysis on one of the products that were studied when the mobile tool was sent to factories. Data for products is divided into primary data and secondary data as mentioned in section 4.

The product used for this case study is one of over 30 products studied using the tool. The product is a wool sweater (50% cotton and 50% wool) that is made in a garment factory Guangdong, China. The fabric is also sourced from China. Each product weighs about 500 grams and they are made for two fashion brands in the United States.

The environmental score for the product is detailed in the next page. Recommendations to factories and brands of how to utilize the score are explained in section 6.

Dimension	*Description*	Source	Unit	μ	σ	S	*score*
Garment Waste	% excess material, in garment manuf.	Mobile Tool (Primary Data)	%	9.9	11.0	1.0	A
Material Score							A
Garment Electricity	in garment manuf.	Mobile Tool (Primary Data)	Watt-hr/$	99	281	20	B
Energy Footprint	50/50 Cotton/wool in comparison with other common garment materials	[15] (secondary Data)	MJ/kg	204	70	151	A
Energy Score	Note: more weight is given to energy footprint as it includes multiple tiers of the supply chain						A-
Garment Water	Water used in garment manuf. per dollar FOB	Mobile Tool (Primary Data)	Milliliter / $	459	486	400	C
Country Water Risk 1	Based on water risk in country of fabric origin	[16] (secondary Data)	Scale 0-6	N/A	N/A	2.9	C
Country Water Risk 2	Based on country of garment factory	[16] (secondary Data)	Scale 0-6	N/A	N/A	2.9	C
Water Score	See **Exhibit 2**, for full list of countries water risk indicators [16]						C
Garment Wastewater	Amount of discharged water per dollar FOB	Mobile Tool (Primary Data)	Milliliter / $	341	342	200	B
Retained Wastewater	% reused water, in garment manuf.	Mobile Tool (Primary Data)	%	11.4	28.4	60	A
Wastewater Score	Note: more weight is given to water treatment, as there is no harm of wastewater as long as it's reused						A-

Overall Score	B+

Table 5: environmental score of studied product

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CHAPTER 6: Recommendations and Conclusion

6.1 Environmental recommendations to factories

Based on the performance of factories, initial recommendations are shared with them. The recommendations will develop as more findings are revealed.

Material Efficiency

- Increase material utilization: this results in cost saving of using fabric to the maximum as well as reduce the cost of waste disposal. Methods of increasing material utilization include better handling of the pattern making process as well as lower defect rate.
- Recycle material wherever possible: in many countries (for example Cambodia), third parties will pay factories to purchase excess fabric.
- Partner with upcycling organizations: there are many fashion companies that would create something new products from abandoned fabric. While making a single cotton t-shirt requires about 700 gallons of water, reusing a an existing t-shirt to make a new product requires very few resources, and nearly no water. Moreover, upcycling can save some of the 85% of textile waste that would have ended up in landfills [17].

Energy Efficiency

- Reducing energy consumption benefits both factories and the environment. Less energy means less costly energy bill as well as fewer greenhouse gas emissions. It also helps factories stay ahead of the curve in terms of new environmental regulations.
- Conducting an energy audit of facilities is a great way to assess energy use and determine how to lower consumption in lighting, building efficiency, heating, cooling, machinery and operations [18].

Water Efficiency

Reducing factory water consumption in the production process helps lower operating costs. It is recommended to create and manage a water management system to measure and maintain the water usage of the facility. The management system also helps identify where an increase of water efficiency is possible. The water management system can be done by following the steps below [18]:

1. Collecting utility records from the facility's water management company
2. Creating location maps to identify each water supply meter that measures incoming water. If meters do not exist, it is recommended to install them
3. Keeping a record of inventory of all plumbing fixtures and water-using equipment with manufacturer's flow rates.
4. Recording irrigation and general outdoor water usage

Wastewater Efficiency

Treating wastewater prior to discharging it reduces the facility's environmental impact and helps prepare for future governmental regulations. In order to implement a successful wastewater management system, you may follow these key steps:

1. Establish a treatment plant and ensure that its discharges meet local and national regulations
2. Discharge samples have to professionally analyzed at qualified labs to verify wastewater composition. Accurate records must be kept.
3. If wastewater is discharged to a septic tank or soak-away, ensure it is properly sized for the discharge volumes, and that it is frequently pumped for its effective operation.

6.2 Interpretation of Data

The scores generated by LET should be treated as a reference point for the overall sustainability of a factory or a piece of garment. Factories and brands can the environmental scores to benchmark their progress towards a much efficient and environmental conscious facilities and products. The score as well as the analysis behind it should not be considered a detailed and thorough evaluation of facilities and products. As more data is collected through future internships and pilots, however, we will have a much larger set of data which will enable us to be more confident of such scores.

6.3 Conclusion

Studying the environmental impact of garment factories and products is difficult. Clothes are made of many fabrics, manufactured in thousands of different factories and have different fabrics that are sourced from multiple countries around the world.

In attempting to overcome these challenges, the Li & Fung Environmental Tool (LET) uses the power of mobile technology, IP location and cloud storage. LET provides great value for factories, brands, Li & Fung itself and beyond.

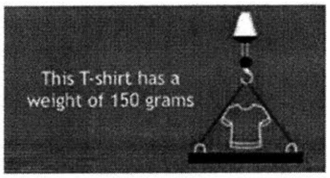
LET is the simplest way to evaluate factories while reducing the resources required for sending personnel to factories to explain, collect and verify environmental data. Such evaluation helps factories benchmarks their performance to other Li & Fung factories. It also helps Li & Fung have a holistic view of the performance of factories by adding that environmental dimension.

The tool also allows brands to obtain detailed information on the environmental of products sourced via Li & Fung. Such information does not only depend on information provided by garment factories, but also based on established research on the impact of the fabric from raw material to final product. Water risk data of the country of fabric origin and the country where the garment manufacturer is also used.

Using mobile tools to withdraw data from suppliers should not be restricted to Li & Fung environmental efforts. Many different organizations in Li & Fung can benefit from the tool and convert it to something that they can use. The days of collecting information on paper (or every spreadsheets) are over. Mobile-and-internet based technologies are ready to take over in making data collection and analysis faster and bigger scaled.

EXHIBIT 1: Screen captures of the mobile tool

Product weight (in grams)



Total FOB of the facility this year

$

Example: $ 30,000,000

FOB of this product

$0.00

Example: $ 1.00

Percent of wasted material

0

Example: 10%

What do you do with waste (extra) material?

Material type 1

Chambray

% of Material 1 used in that product

0

For example: 70% cotton

Material type 2:

Chambray

% of Material 2 used in that product:

0

For example: 70% cotton

Countries of sourced fabric

Afghanistan

Select all that apply

Countries of raw materials

Afghanistan

Select all that apply

Take a picture of the final product

Energy Information [Part 4 of 6]

Total Electricity usage in last three (3) month (kWh)

For example: 10,000 kWh + 12,000 kWh + 11,000 kWh = 33,000 kWh

Take a picture or upload a scanned copy of

Do you use natural gas?

Yes

No

Take a picture or upload a scanned copy of the gas bill for last month

Choose File No file chosen

File uploads may not work on some mobile devices.

Take a picture or upload a scanned copy of the gas bill for month 2

Choose File No file chosen

File uploads may not work on some mobile devices.

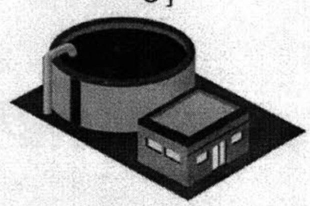
Take a picture or upload a scanned copy of the gas bill for month 3

Choose File No file chosen

File uploads may not work on some mobile devices.

Save and Resume Later

Wastewater Information [Part 6 of 6]



Monthly amount of wastewater (or estimate)

Units for wastewater

Monthly amount of reused wastewater (or estimate)

Thanks you!

Your feedback is appreciated! We will use the data to improve sustainability practice!

Kindly sign then click submit

[clear]

Save and Resume Later

Submit Form

Powered by Formstack

EXHIBIT 2: Aqueduct Country Water Stress Ranking for 2010

Table A2 | Aqueduct Country Water Stress Ranking for 2010 using Updated Aqueduct Global Maps 2.1

RANK	NAME	ALL SECTORS	INDUSTRIAL	DOMESTIC	AGRICULTURAL
1	Bahrain	5.00	5.00	5.00	5.00
1	Qatar	5.00	5.00	5.00	5.00
1	San Marino	5.00	5.00	5.00	5.00
1	Singapore	5.00	5.00	5.00	No data
5	United Arab Emirates	5.00	5.00	5.00	5.00
6	Saudi Arabia	5.00	5.00	4.97	5.00
7	Kuwait	4.97	4.90	4.97	4.97
8	Oman	4.95	4.97	4.97	4.95
9	Kyrgyzstan	4.93	4.97	4.94	4.93
10	Iran	4.79	4.47	4.70	4.80
11	Yemen	4.76	4.08	4.71	4.78
12	Libya	4.74	4.65	4.42	4.82
13	Israel	4.73	4.69	4.80	4.70
14	Kazakhstan	4.50	4.30	4.32	4.55
15	Palestine	4.45	4.49	4.39	4.50
16	Jordan	4.30	4.28	4.36	4.27

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Table A2 | Aqueduct Country Water Stress Ranking for 2010 using Updated Aqueduct Global Maps 2.1 (continued)

RANK	NAME	ALL SECTORS	INDUSTRIAL	DOMESTIC	AGRICULTURAL
17	Pakistan	4.25	4.06	4.06	4.26
18	Lebanon	4.23	4.26	4.28	4.20
19	Uzbekistan	4.20	4.46	4.45	4.17
20	Mongolia	4.08	4.82	4.23	3.27
21	Azerbaijan	4.01	4.24	4.03	3.92
22	Turkmenistan	4.00	3.85	3.27	4.03
23	Armenia	3.93	4.03	3.90	3.93
24	Syria	3.86	3.81	3.75	3.87
25	Morocco	3.85	3.57	3.54	3.91
26	Afghanistan	3.76	3.70	3.43	3.77
27	Iraq	3.67	3.15	3.50	3.75
28	India	3.62	3.46	3.10	3.67
29	Greece	3.60	3.14	3.29	3.64
30	Taiwan	3.52	3.65	2.93	2.76
31	Spain	3.51	3.34	3.50	3.57
32	Timor-Leste	3.45	2.51	2.97	3.50
33	Dominican Republic	3.44	3.15	3.26	3.52
34	Italy	3.42	3.45	3.64	3.30
35	Monaco	3.41	3.41	3.41	3.41
36	Belgium	3.39	3.38	3.45	3.13
37	Eritrea	3.34	2.38	3.61	3.32
38	Macedonia	3.34	3.27	3.27	3.45
39	Tajikistan	3.34	2.94	3.25	3.37
40	Mexico	3.32	2.66	2.70	3.51
41	Turkey	3.32	3.27	3.27	3.35
42	Tunisia	3.27	3.42	3.34	3.25
43	Australia	3.24	3.03	3.28	3.26
44	Peru	3.20	3.26	2.75	3.24
45	China	3.10	3.08	2.74	3.18
46	Portugal	3.06	3.16	3.23	2.98
47	Andorra	3.05	2.88	3.05	3.13
48	Algeria	3.04	3.41	2.96	2.95
49	United States	3.01	2.57	2.71	3.70
50	South Korea	2.92	3.32	2.99	2.78
51	South Africa	2.90	3.20	2.52	3.06
52	Chile	2.90	3.19	3.31	2.67
53	Indonesia	2.88	2.30	2.59	3.05
54	Ukraine	2.81	2.46	2.64	3.12
55	Luxembourg	2.80	2.79	2.81	2.79

Table A2 | Aqueduct Country Water Stress Ranking for 2010 using Updated Aqueduct Global Maps 2.1 (continued)

RANK	NAME	ALL SECTORS	INDUSTRIAL	DOMESTIC	AGRICULTURAL
56	Philippines	2.78	2.50	2.56	2.83
57	Cuba	2.76	2.65	2.59	2.85
58	Ireland	2.75	0.82	1.61	3.23
59	Sri Lanka	2.68	2.25	1.96	2.77
60	Japan	2.53	2.78	2.74	2.40
61	United Kingdom	2.52	2.33	2.62	2.90
62	Swaziland	2.41	1.79	1.80	2.46
63	Argentina	2.37	1.92	2.19	2.58
64	Germany	2.19	2.24	1.99	2.03
65	Nepal	2.19	2.34	2.29	2.19
66	Haiti	2.19	1.93	2.10	2.23
67	Moldova	2.12	2.26	2.06	1.96
68	Venezuela	2.07	1.80	2.33	1.75
69	Albania	2.07	2.16	2.26	1.90
70	France	1.98	2.09	1.88	1.60
71	North Korea	1.85	2.07	1.68	1.83
72	Georgia	1.82	1.75	1.59	1.96
73	Ecuador	1.79	1.24	1.45	1.86
74	Somalia	1.79	4.26	1.86	1.78
75	Namibia	1.75	3.36	1.71	1.57
76	Bulgaria	1.74	1.52	2.06	2.30
77	Thailand	1.72	1.40	1.41	1.76
78	Netherlands	1.68	1.69	1.57	1.70
79	Kosovo	1.66	1.69	1.64	1.58
80	Poland	1.65	1.67	1.53	1.85
81	Lithuania	1.60	1.60	1.62	1.54
82	Estonia	1.59	1.59	1.71	0.73
83	Czech Republic	1.54	1.59	1.46	1.60
84	Botswana	1.48	1.31	2.19	0.44
85	Russia	1.43	1.12	1.62	2.19
86	Malaysia	1.39	1.37	1.29	1.49
87	United Republic of Tanzania	1.38	0.79	0.38	1.64
88	Romania	1.34	1.32	1.59	1.07
89	Canada	1.21	1.17	0.73	2.71
90	Egypt	1.19	1.44	0.96	1.19
91	Lesotho	1.17	1.17	1.17	1.17
92	Angola	1.13	1.82	0.35	0.92
93	Sweden	1.12	1.28	0.89	0.75
94	Vietnam	1.09	1.30	1.18	1.07

Table A2 | Aqueduct Country Water Stress Ranking for 2010 using Updated Aqueduct Global Maps 2.1 (continued)

RANK	NAME	ALL SECTORS	INDUSTRIAL	DOMESTIC	AGRICULTURAL
95	Belarus	1.08	1.05	1.08	1.19
96	Madagascar	1.01	0.96	0.66	1.02
97	Switzerland	0.99	1.06	1.01	1.24
98	Sudan	0.95	0.76	1.00	0.97
99	Costa Rica	0.93	0.67	0.83	1.05
100	Hungary	0.91	0.84	0.97	1.14
101	Uruguay	0.85	1.02	1.13	0.75
102	Brazil	0.84	0.84	0.99	0.78
103	Djibouti	0.82	1.17	0.92	0.55
104	Ethiopia	0.81	0.80	0.53	0.85
105	New Zealand	0.78	0.54	0.79	0.81
106	Republic of Serbia	0.77	0.74	0.96	0.36
107	Kenya	0.76	0.81	0.47	0.86
108	Guyana	0.71	0.43	0.50	0.72
109	Guatemala	0.69	0.82	0.27	0.76
110	Finland	0.67	0.59	0.94	0.74
111	Bolivia	0.64	0.73	0.47	0.73
112	Zimbabwe	0.56	0.78	0.40	0.56
113	Belize	0.55	0.53	0.53	0.67
114	Gambia	0.54	0.89	0.53	0.01
115	Montenegro	0.51	0.62	0.45	0.61
116	Mozambique	0.49	1.26	0.35	0.45
117	Senegal	0.49	0.96	0.62	0.46
118	Denmark	0.48	0.46	0.65	0.21
119	Mauritania	0.47	3.37	0.89	0.36
120	Cambodia	0.46	0.21	0.42	0.47
121	Latvia	0.43	0.41	0.46	0.43
122	Liechtenstein	0.42	0.42	0.42	No data
123	Austria	0.41	0.39	0.35	1.30
124	Chad	0.37	0.19	0.07	0.69
125	Papua New Guinea	0.34	0.39	0.31	No data
126	Slovakia	0.33	0.27	0.43	0.29
127	Nigeria	0.33	0.10	0.21	0.61
128	Nicaragua	0.33	0.34	0.22	0.37
129	Norway	0.30	0.16	0.52	0.20
130	El Salvador	0.28	0.20	0.24	0.34
131	Mali	0.26	0.18	0.25	0.27
132	Suriname	0.26	0.01	0.01	0.30
133	Liberia	0.24	0.67	0.05	0.00

Table A2 | Aqueduct Country Water Stress Ranking for 2010 using Updated Aqueduct Global Maps 2.1 (continued)

RANK	NAME	ALL SECTORS	INDUSTRIAL	DOMESTIC	AGRICULTURAL
134	Bangladesh	0.22	0.20	0.23	0.21
135	Myanmar	0.21	0.49	0.23	0.19
136	Colombia	0.17	0.18	0.17	0.18
137	Ghana	0.16	0.31	0.18	0.08
138	Slovenia	0.15	0.15	0.13	0.17
139	Togo	0.14	0.57	0.17	0.00
140	Bosnia and Herzegovina	0.14	0.16	0.14	0.01
141	Niger	0.12	0.96	0.12	0.07
142	Croatia	0.09	0.10	0.09	0.03
143	Guinea	0.05	0.04	0.02	0.06
144	Ivory Coast	0.02	0.04	0.04	0.00
145	Laos	0.02	0.02	0.02	0.02
146	Honduras	0.02	0.01	0.01	0.02
147	Cameroon	0.01	0.00	0.02	0.00
148	Sierra Leone	0.01	0.03	0.01	0.00
149	Panama	0.00	0.00	0.00	0.01
150	Paraguay	0.00	0.01	0.00	0.00
151	Uganda	0.00	0.00	0.00	0.00
152	Burkina Faso	0.00	0.00	0.00	0.00
153	Benin	0.00	0.00	0.00	0.00
153	Bhutan	0.00	0.00	0.00	0.00
153	Brunei	0.00	0.00	0.00	0.00
153	Burundi	0.00	0.00	0.00	0.00
153	Central African Republic	0.00	0.00	0.00	0.00
153	Democratic Republic of the Congo	0.00	0.00	0.00	0.00
153	Equatorial Guinea	0.00	0.00	0.00	No data
153	Gabon	0.00	0.00	0.00	0.00
153	Guinea Bissau	0.00	0.00	0.00	0.00
153	Iceland	0.00	0.00	0.00	No data
153	Malawi	0.00	0.00	0.00	0.00
153	Republic of Congo	0.00	0.00	0.00	0.00
153	Rwanda	0.00	0.00	0.00	0.00
153	South Sudan	0.00	0.00	0.00	0.00
153	Zambia	0.00	0.00	0.00	0.00

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