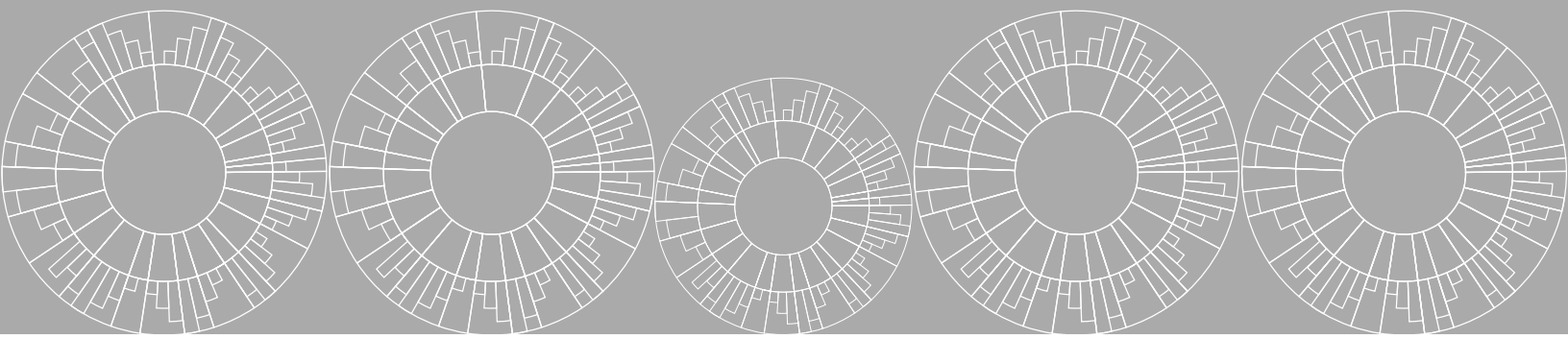
Embedding
PROJECT

Life Cycle Thinking

A GUIDE



Stephanie Bertels
Rachel Dekker

Life Cycle Thinking

A Guide

Prepared by Stephanie Bertels and Rachel Dekker

Stephanie Bertels and Rachel Dekker (2023). *Life Cycle Thinking*. Embedding Project. 10.6084/m9.figshare.23992887

Embedding PROJECT

Contents

Introduction 4

What is life cycle thinking? 5

The value of life cycle thinking 7

Conceptual Life Cycle Mapping 8

Conceptual life cycle mapping for products 9

Conceptual life cycle mapping: A seven step process 11

Life cycle mapping for services or processes 32

Acknowledgements 34

Embedding PROJECT

Introduction

Life cycle thinking is rapidly becoming a foundational tool for sustainability teams, product designers, and, increasingly, procurement and supply chain professionals and even executive teams. Even a basic conceptual life cycle map can provide important insights into the environmental and social impacts of a product, service, or process, help to assess how it compares to other options, identify potential sustainability risks, and surface new opportunities to reduce its direct and indirect impacts.

Life cycle thinking can be employed by everyone. This guide introduces the practice of life cycle thinking and walks you through the process of developing a simple conceptual life cycle map. This process and the outputs that it produces help you to better consider the environmental and social impacts of the products, services, and processes that your company produces or that it buys across their full life cycle and to identify strategies to improve them.

What is life cycle thinking?

Life cycle thinking is a way of conceptually understanding (and in the case of life cycle assessment – quantifying) the environmental and social impacts of your products, processes, and services across their full life from the point of creation all the way through to the end of their useful life.

Life cycle thinking is anchored in systems thinking and whole-systems approaches, which bring an awareness that our choices are not isolated, but instead, influence a larger system.[1],[2] If we want to support people and the planet, we need to minimise our impact on the environment and ensure that our actions contribute to society, instead of harming it.

That means that companies need to view themselves as part of a nested system, bounded by, and embedded within, the environmental and social systems in which they operate. It also means they need to take a more systematic approach to understanding the full environmental and social life cycle of the products and services that they produce and the processes they use to produce them.[3]

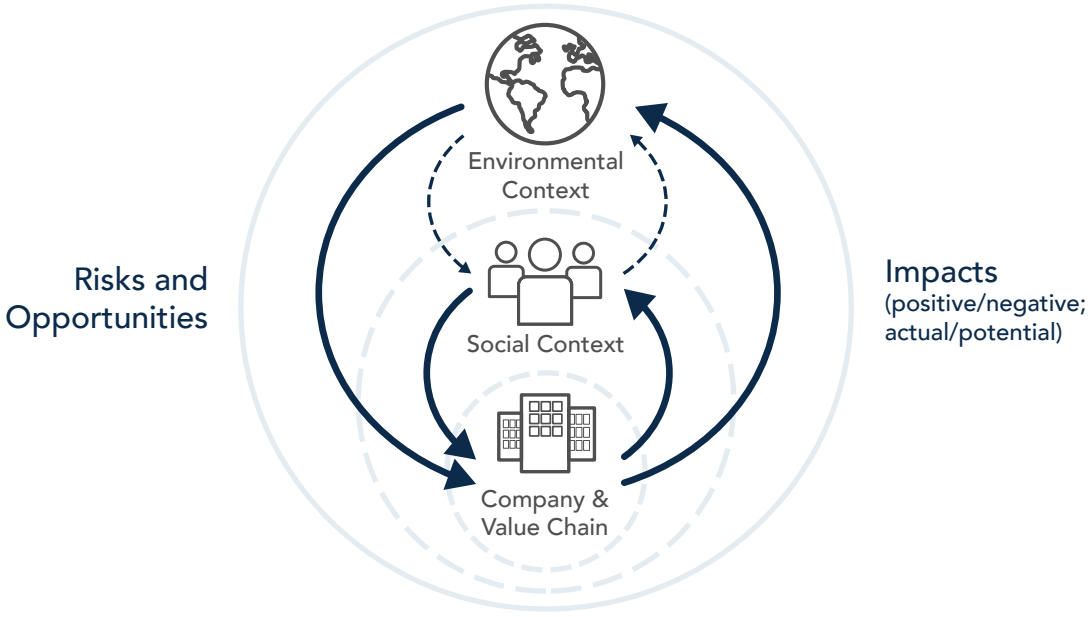


Figure 1: Companies are embedded in a social and environmental context.

[1] For more information see: Meadows, Thinking in Systems: A Primer. Chelsea Green Publishing, 2008
[2] UNEP (United Nations Environment Programme), Why Take a Life Cycle Approach?
[3] United Nations Environment Programme, Life Cycle Management: A Business Guide to Sustainability

Life cycle thinking helps a range of users, including companies, consumers, and governments, begin to identify the most significant environmental and social impacts across their value chains, as well as areas where improvements can be made. Since environmental and social systems are often interconnected, life cycle thinking can also help to prevent inadvertent shifting of impacts from one life cycle stage to another, from one region to another, or from one environmental or social impact to another.[4] For instance, you might learn that reducing energy consumption at one stage may increase water consumption at another stage, or that increasing resource efficiency through automation may lead to job losses or drive down wages. Life cycle thinking can help you to be more attentive to the unintentional impacts of your actions and offers the opportunity to try to prevent or mitigate those impacts.

Life cycle approaches can range from being more qualitative (such as conceptual life cycle mapping) to being more rigorous, comprehensive, and quantitative (like life cycle assessments). You will want to match the rigour of your analysis to its intended purpose.

A rough conceptual life cycle map can take a few hours, yet still identify potential risks and opportunities that merit further investigation. But, you will likely need a proper life cycle assessment (LCA) that makes use of recognised, standardised methodologies, if you want to make claims that your product, process, or service is environmentally and/or socially preferable to that of your competitor, that it meets government or other standards, or if you need submit carbon footprint data to a customer as part of their Scope 3 enquiries. A full LCA may take hundreds of hours and will very likely require the input of trained professionals. If that's your objective, you may also be interested in reading another of our guides, *Life Cycle Assessment: A beginner's guide*, which provides an introductory overview of LCA, why companies may want to undertake one, and what to know before you reach out to an LCA consultant.

In the meantime, let's learn a bit more about the basics of life cycle thinking.

[4] European Union, Making Sustainable Consumption and Production a Reality: A guide for business and policymakers to Life Cycle Thinking and Assessment, doi: 10.2779/91521

The value of life cycle thinking

Individuals, organisations, governments, and businesses ranging from small and medium sized enterprises (SMEs) to large multi-nationals, can use life cycle thinking to inform what products they choose to buy; to design a new or improved product, process, or service; or even to inform government policy. It is a useful tool for anyone as they think about the products that they use, where they come from, and whether they contribute to, or erode, social and environmental systems.

For businesses, life cycle thinking helps to:

- identify your company's most significant environmental and social impacts and opportunities to improve its social and environmental performance and/or systems resilience;
- identify strategic and value chain risks and opportunities;
- guide the development of new products, processes, and services;
- identify the potential unintended consequences of changes to processes, products, or services; and
- compare your impacts and performance against those of your competitors and potentially differentiate your company's processes, products, or services.

Conceptual Life Cycle Mapping

In this section, we will discuss how to engage in the conceptual life cycle mapping of a product, process, or service. Conceptual life cycle mapping helps you think about the products, processes, and services that you use or produce, where they come from, and how to determine whether they contribute to, or erode, the resilience of social and environmental systems. The process can also help you to better understand where changes can be made to reduce the impacts on those systems.

In contrast with a more detailed life cycle assessment (LCA), conceptual life cycle mapping is something that anyone can do. A very rough conceptual life cycle mapping process can be undertaken in a few hours with limited resources. With a bit more effort, you can begin to identify where you need more data, as well as what potential risks and opportunities merit further investigation. You may even be able to begin to identify and prioritise possible solutions.

In this guide, we start by illustrating the conceptual life cycle mapping process for products. At the end of the guide, we discuss how this approach can be adapted to processes and services.

Conceptual life cycle mapping for products

From a product perspective, life cycle thinking is about going beyond the traditional focus on product development and marketing. The objective is to understand and improve the environmental, social, and economic impacts of a product at all stages of its life cycle. As depicted below, this begins with understanding the key stages of your product's life cycle, including generating and harvesting the raw materials, processing these raw materials into components, assembling and packaging your product, distributing and selling it, through to customer use and/or consumption, and ending with the recovery and/or recycling of materials, disposal to landfill, conversion into heat or energy, or even uncontrolled release into the environment. You will also need to consider the impacts from transportation and the impacts on workers that may occur across the cycle.

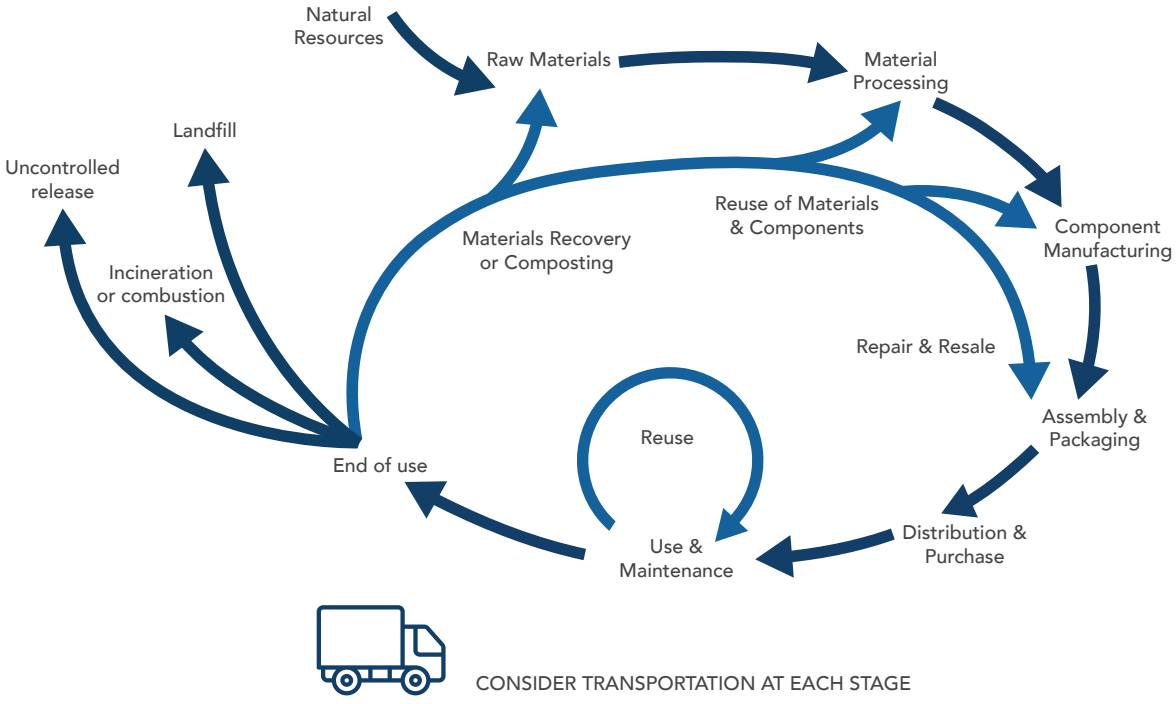


Figure 2: Life cycle of a product: key stages.

[5] United Nations Environment Programme, Life Cycle Management: A Business Guide to Sustainability https://www.unep.org/resources/report/life-cycle-management-business-guide-sustainability

[6] Adapted from United Nations Environment Programme, Life Cycle Management: A Business Guide to Sustainability

Raw material extraction & material processing

Your product's life cycle begins with generating and harvesting raw materials. This includes crops, minerals, hydrocarbons, water, nutrients, and other materials. Next, those raw materials need to be processed. Ores might be turned into metal alloys, wood might be turned into lumber or pulp, crude oil needs to be refined, and crops need to be processed into ingredients or products.

Component manufacturing, assembly & packaging

Unless your product is a commodity, it will likely need to be manufactured. Depending on its complexity, it may need to be assembled from sub-components. Your product will need to be packaged and may also require cleaning, starching, sterilisation, or another treatment before being packaged, along with adding labels and other documentation.

Distribution & sale

Your product will need to be distributed, likely warehoused, and then sold and delivered to the end-customer.

Use, maintenance & reuse

Your product will be used by the end-customer and may need to be stored, refrigerated, consumed, or even combusted. It may require energy or fuel to operate it. It may need to be maintained, cleaned, and have parts replaced or upgraded. You will want to think about how many times the product might be used in its lifetime and the frequency of any required maintenance.

Disassembly, repurposing, recycling, composting, incineration, or landfilling

The end-consumer will need to dispose of the packaging. At some point, they will also need to dispose of your product. They may consume it entirely, or if not, you will need to consider where your product will go, whether that is composting, recycling, reuse, disassembled for materials or component recovery, landfilling, or combustion. Some products, parts of products, or by-products can also end up accumulating in the natural environment.

Transportation

Whether it is the raw materials, the components, the product, or the end-of-life waste, transportation is likely to occur throughout the product life cycle, via trains, trucks, bicycles, cars, sea vessels, or airplanes.

Let's not forget people

Finally, it is important to remember that at each stage, people are required to do this work and that all this work takes place in the context of communities, meaning it creates social impacts along with environmental impacts across your product's life cycle.

Conceptual life cycle mapping: A seven step process

Below, we outline a simple seven step process that you can undertake in a few hours to a few days. The process covers developing a conceptual life cycle map, identifying what the key environmental and social impacts might be, and developing a strategy for how to apply what you have learned.

We will illustrate this process by mapping the life cycle of a product (a cotton t-shirt). But you can apply the same process to map the life cycle of a service or a process. To illustrate how this same process could be undertaken for a service, we provide the example of a hotel stay at a safari lodge at the end of this guide.

Step 1: Determine your functional unit and your system boundaries.

One of the first things you need to do as you map out the life cycle of your product is to determine its functional unit and make some assumptions about the boundaries of your system.

Functional units

The functional unit is your unit of analysis – it describes the product, service, or system whose impacts are being calculated. When selecting functional units, the aim is to choose a unit that allows for fair comparisons between your product or service and other alternatives that could serve the same purpose.

As the term implies, the focus is on the 'function' that it performs. If you are undertaking a full LCA, this will be an involved process and you will need to adhere to a recognised standard. For the current conceptual life cycle mapping, you might think about these basic features[7]:

- the function(s) performed/service(s) provided
- an appropriate 'unit' for the provision of the function
- and whether there are important criteria related to its quality, function, and/or durability

What if you wanted to compare a ceramic coffee mug to a paper cup? While the ceramic cup has a large initial footprint, it can be used many more times than the paper cup. But the function of the cups in the same – to hold your coffee or tea and get it safely into your mouth. So, our functional unit could be "the storage and delivery of one 250ml serving of a hot beverage." Common examples of other food-related functional units are 1 kg of beef, 100 calories of food, or 1 ha of land.

For our t-shirt, we could set our functional unit as one wearing of a t-shirt. If we wanted to be a bit more specific, we might set it as one wearing of a 100% conventional cotton white t-shirt.

[7] Weidema, Short procedural guideline to identify the functional unit for a product environmental footprint and to delimit the scope of product categories, https://lca-net.com/files/Granularity-guideline-FINAL_20170331.pdf

As you can imagine, this has implications for how we can compare our life cycle mapping (or a full-fledged LCA) to those of other t-shirts performing the same (or similar) function. For instance, we may want to compare the life cycle of our conventional cotton t-shirt to that of an organic cotton t-shirt, a polyester t-shirt, or perhaps a t-shirt made from recycled ocean plastic. It also helps us to evaluate the benefits of making a t-shirt that is more durable and/or easier to clean, so that it can be worn more frequently and washed using less energy and water. In a full life cycle analysis, we would want to get even more specific. For instance, we might want to specify the size of the t-shirt to be able to accurately measure weight or volume of the materials required and what colour/dye we were using to understand their chemical components and possible impacts. You would also need to make assumptions about the use phase, including that the t-shirt is likely to be worn about 10 times a year, last about 5 years, and that it will be washed each time it is worn.

For conceptual mapping, you can start by focusing on the key function and define it in a way that would allow for comparisons between your product and other possible alternatives. So, for a dishwasher, its function might be the ability to wash a load of dishes equivalent to 12 full place settings (then you could compare the performance of a dishwasher to a similar amount of hand washing).

Determining the boundaries of your study

The other crucial decisions you need to make relate to the boundaries you set on your analysis. Some important boundaries to consider are:

Scope: How 'far' does you extend your analysis? Some life cycles consider everything that happens upstream from the raw materials (such as the growing and harvesting of crops) through to the manufacturing and arrival to the customer – they are often called cradle to gate assessments. By contrast, other life cycles start with everything upstream and then also consider the downstream impacts of customer use and maintenance and carry on through to the final stages of materials recovery or waste generation. They are often called cradle to cradle assessments, meaning that they go all the way around the full life of the product.

You will also need to make some decisions about what is included and not included in your analysis. Will you include the impacts of the thread along with the fabric? What about the labels? What about the packaging?

As you can well imagine, when your product contains multiple components, deriving from multiple raw materials, from multiple different sources, your system becomes very complex, very quickly. In a formal LCA, the standard you follow will provide guidance on what is 'in scope' and 'out of scope'. Often, you will also require the data from a separate LCA of the individual materials and/or components used to produce your product.

In conceptual life cycle mapping, you will need to be pragmatic. This may mean focusing on major components and materials and/or those with potentially high social or environmental impacts. When you do this, just be clear about stating your assumptions: you will need to carry them forward as potential limitations on your recommendations.

For instance, in our example of the life cycle of a t-shirt, we are focusing on the fabric and thread and have not considered the impacts from the fabric and cardboard labels that we will attach to our shirt, or the plastic tags that we will use to attach them or the polybags in which we ship them to our stores and customers.

Geography: You will need to make some decisions about the geographical focus of your assessment in terms of where you source your materials, produce your product, and where it is consumed. Geography plays a crucial role in most life cycle studies. Regulations protecting workers and the environment vary by jurisdiction, as do the levels of resilience (or vulnerability) of ecosystems and social systems. Geography also plays an important role in the transportation footprint of your product. And local behaviours regarding water and energy use or waste management may affect the downstream impacts of your product, as efficient equipment may not be readily available, or reuse/repurpose/recycle practices may not be the norm.

In our example, we might assume that our cotton is grown in India, that weaving of the fabric and manufacturing of the garment takes place in Bangladesh, and that our consumer is in North America.

An additional boundary that you may want to consider relates to current vs. expected or future conditions. For instance, are you assuming presently available technology or are you modelling the potential for future technology?

Step 2: Map the key stages in the life cycle of the product.

Your next task will be to map out the key stages and processes in the life cycle of your product. Drawing a diagram is very useful at this stage.

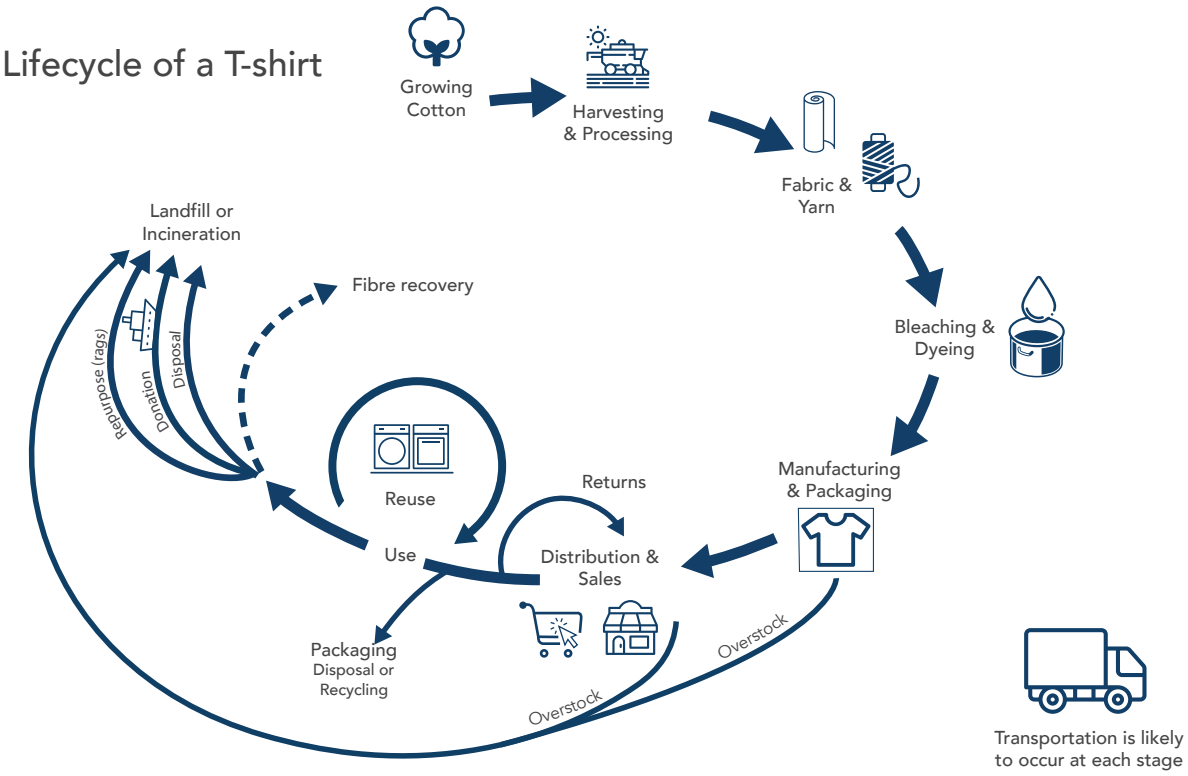


Figure 3: Life cycle of a t-shirt: key stages

Raw material extraction & processing

Our t-shirt's life cycle begins with growing cotton. Cotton grows in warm climates and most of the world's cotton is grown in the United States of America, Uzbekistan, the People's Republic of China, and India.[8] Cotton needs soil, water, nutrients, and energy from the sun. Producers plough or till the soil, and plant seeds in rows. The cotton plant produces pods called cotton bolls. Inside the boll, moist fibres grow that expand and, eventually, fluffy cotton bursts out. These days, cotton is predominantly harvested by machines (a picker or a stripper). Once picked, it is run through a cotton gin, dried, cleaned, and pressed into large bails.

[8] Cotton Counts, The Story of Cotton, https://www.cotton.org/pubs/cottoncounts/story/how.cfm

Component manufacturing, assembly & packaging

The raw cotton fibres are carded and spun into yarn and woven into fabric. Our fabric is bleached and dyed. The fabric is sewn into a t-shirt which is labelled and packaged into a low-density, polyethylene, #4 virgin plastic film bag to protect it on its journey.

Distribution & sale

Our t-shirt is shipped to North America and trucked to a distribution centre. It will either be trucked to a store where it will be driven home by a customer or flown and/or trucked to an online customer. According to recent estimates, 30 percent of garments produced annually are never actually sold: this is called overstock.[9]

Use, maintenance & reuse

Our North American consumer is unlikely to wear their t-shirt more than 10 times, but they will likely wash it every time they wear it.[10] They are also unlikely to repair it since they can likely find a replacement at an affordable price point.

Disassembly, repurposing, recycling, composting, incineration, or landfilling

If our t-shirt is worn out, lost its shape, or is stained, it is likely to be thrown in the garbage or be used as a rag and then thrown away. In these cases, it will either end up in a landfill or in a waste-to-energy plant. Our t-shirt might also be donated, but rather than staying in North America and being purchased by a new owner, it is much more likely to be bundled up with other clothing in a bulk shipment to the Global South. About 70 percent of the clothing donated around the world eventually finds its way to Africa, where it often ends up in landfills.[11,12]

---

[9] Share Cloth, The 2018 Apparel Industry Overproduction Report and Infographic, https://medium.com/nataliya-makulova/the-2018-apparel-industry-overproduction-report-and-infographic-by-sharecloth-284cda8f1f9

[10] Morgan & Birtwistle, An investigation of young fashion consumers' disposal habits, https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1470-6431.2009.00756.x

[11] Lee, The Truth About Where Your Donated Clothes End Up, https://abcnews.go.com/WN/truth-donated-clothes-end/story?id=2743456; Franklin-Wallis, What Really Happens to the Clothes You Donate https://www.gq.com/story/oliver-franklin-wallis-wasteland-excerpt

[12] Changing Markets Foundation, Fossil Fashion, https://changingmarkets.org/portfolio/fossil-fashion/

Transportation

Our t-shirt is a world traveller along its entire life cycle. From its birth as cotton grown in India to the textile mill and factory in Bangladesh, to our consumer in North America, and to its likely final destination in Africa, it travels around the world and back again.

Labour

At almost every stage, workers are involved in the process, whether it be farming and harvesting, operating machinery and equipment at mills, processing facilities, and garment factories, transporting materials and products, marketing and retail, or waste management. It will be important to understand the health, wellbeing, treatment, working conditions, compensation, dignity, and respect for the rights of these workers at each stage.

Step 3: Map the key environmental impacts

Now it is time to think about your product's life cycle from an environmental perspective. You will need to research the environmental impacts associated with sourcing and processing your raw materials, the manufacturing of your product, the impacts of a customer's use of your product, what it takes to maintain your product, the options for dealing with your product at the end of its useful life, and all the treatment, packaging, and transportation required along the way.

Pressure for companies to report on the carbon footprint of their products means that most life cycle studies focus on greenhouse gas emissions. But to gain a holistic view of your product's impact on ecological systems, you will want to consider several environmental impact categories at the same time.

Here are some issues that you may want to consider:

- Greenhouse gas emissions / energy intensive processes
- Water quantity, water quality, and water governance
- Biodiversity, habitat loss, species loss, potential impacts on culturally significant species and landforms, loss of ecosystem services, the introduction of invasive species, land use change, impacts on soil quality and health, loss of topsoil, and impacts on and use of protected spaces
- Waste and resource inefficiency, process residuals (including tailings, slag, sludge, and waste heat); hazardous wastes, packaging, and overstock
- Pollutants (including nitrogen and phosphorous; hazardous chemicals; particulates; biological pollutants; emissions; heavy metals; radiation; light; and noise)

Let's take a look at some of the key environmental issues in the life cycle of a t-shirt.

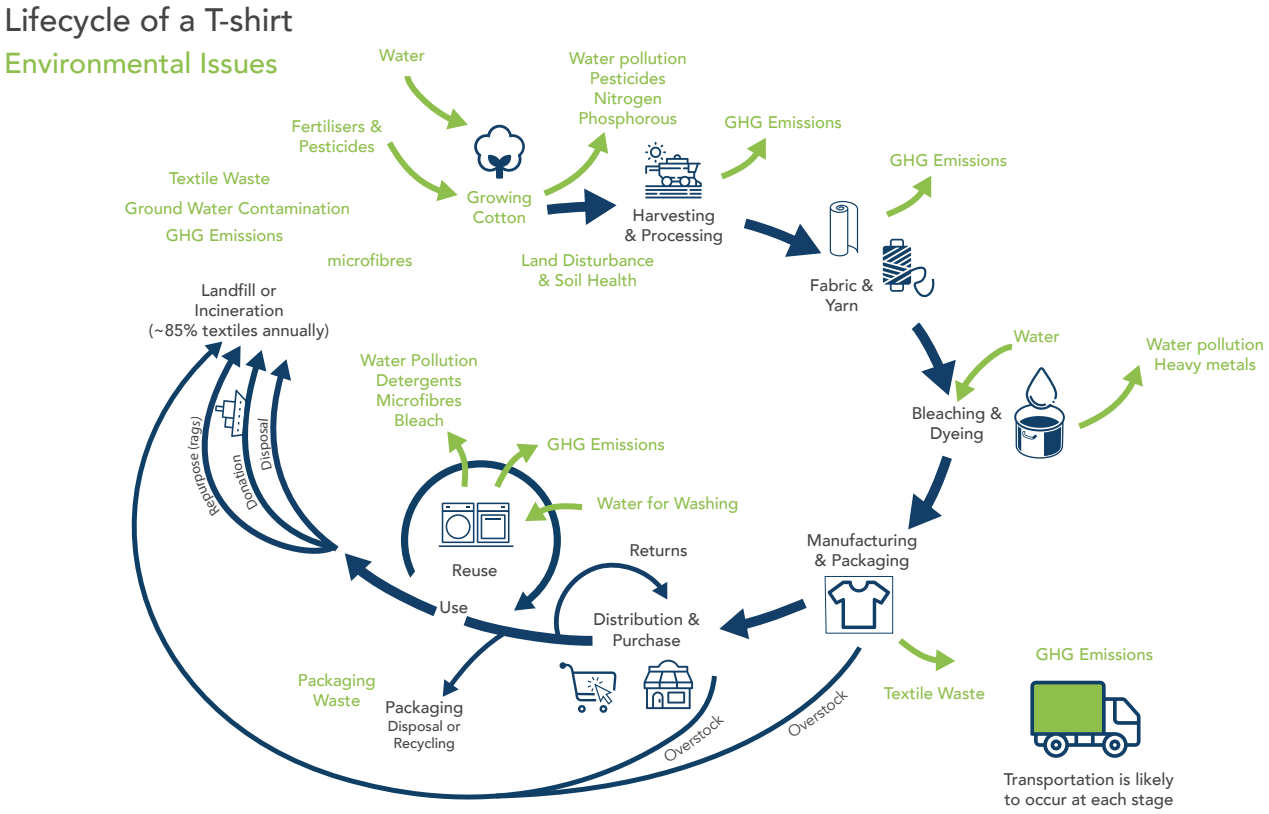


Figure 4: Life cycle of a t-shirt: environmental issues

Raw material extraction & processing

It takes a lot of water to produce the cotton needed to make a t-shirt. Producing one kilogram of cotton requires between 6,800 and 29,000 litres of water, depending on where it is grown.[13] Our t-shirt, weighing 150 grams, requires between 1,020 and 4,350 litres of water.

Only about one percent of global freshwater is accessible (the rest is ice), and approximately 70 percent of that is used for agriculture. Cotton production uses three percent of the agricultural water supply.

Producing cotton also takes a lot of pesticides and synthetic and organic fertilisers that often end up as run-off, contaminating groundwater and rivers, eroding soils, and potentially causing algae blooms.[14] Approximately 16 percent of all insecticides used are used in cotton production.[15] Harvesting, sorting, drying, cleaning, and bailing the cotton all take energy and typically generate greenhouse gas emissions.

Component manufacturing, assembly & packaging

Energy is also needed to spin the yarn and weave the fabric, as well as to cut and sew the fabric into a t-shirt. These processes also need energy and will typically generate greenhouse gas emissions. Textile waste is generated at this stage in the form of offcuts (the scraps of fabric that remain) or in the rolls of fabric that are purchased, but never turned into clothes. And clothing brands often over-produce their clothing lines to avoid disappointing customers.

During the dyeing process, approximately 10-15 percent of dyes are discharged into the water system, killing algae, and often damaging aquatic life, while also polluting drinking water and disrupting the food chain.[16]

---

[13] World Wildlife Fund, Living Waters: Conserving the Source of Life, https://wwf.panda.org/?3692/Living-Waters-Conserving-the-source-of-
[14] Szmydke-Cacciapalle, Making Jeans Green: Linking Sustainability, Business, and Fashion, https://www.routledge.com/Making-Jeans-Green-Linking-Sustainability-Business-and-Fashion-1st-Edition/Szmydke-Cacciapalle/p/book/9780815391876
[15] Environmental Implications of Excess Fertilizer and Manure on Water Quality https://www.ag.ndsu.edu/publications/environment-natural-resources/environmental-implications-of-excess-fertilizer-and-manure-on-water-quality
[16] Natural Resources Defense Council, Clearing Up Your Choices on Cotton, https://www.nrdc.org/sites/default/files/CBD_FiberFacts_Cotton.pdf

Distribution and sale

Many t-shirts are likely to go unsold and may end up going straight to the landfill or incineration.[17] In addition, online customers frequently purchase more than they need, only to return it, resulting in additional greenhouse gas emissions.

Use, maintenance & reuse

By far, two of the most important determinants of the environmental impact of a t-shirt are the number of times consumers wear a garment before throwing it out and how often they wash it.[18] Extending the number of times that a shirt gets worn reduces the impact per wear. Another key factor is wearing clothing more often between washings. It has been estimated that up to 70 percent of the carbon emissions created during the life of a typical cotton t-shirt are due to washing and drying — more than double the amount generated during its production.[19] Laundering is also a water intensive process, can be energy-intensive depending on washing and rinsing water temperatures, and results in the release of detergents and micro-fibres.

Disassembly, repurposing, recycling, composting, incineration, or landfilling

If our t-shirt has a tear or a stain, it is likely to be thrown in the garbage or end up used as a rag and then thrown away. In these cases, it will either end up in a landfill or be processed in a waste to energy plant. Nearly 60 percent of all clothing produced ends up in incinerators or landfills within a few years of being made.[20] And an estimated $500 billion USD of value is lost every year due to clothing underutilisation and lack of recycling.[21]

---

[17] Paton, H&M, a Fashion Giant, Has a Problem: $4.3 Billion in Unsold Clothes, https://www.nytimes.com/2018/03/27/business/hm-clothes-stock-sales.html
[18] Hurst, What's the Environmental Footprint of a T-Shirt? https://www.smithsonianmag.com/innovation/whats-environmental-footprint-t-shirt-180962885/
[19] Steinberger et al, A spatially explicit life cycle inventory of the global textile chain, https://www.academia.edu/8470752/A_spatially_explicit_life_cycle_inventory_of_the_global_textile_chain
[20] Remy, Speelman, and Swartz, Style that's sustainable: A new fast-fashion formula, https://www.mckinsey.com/business-functions/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula#
[21] UN Alliance for Sustainable Fashion https://unfashionalliance.org/

Most of the clothing we donate piles up in landfills, producing toxic leachate, groundwater contamination, and releasing methane, a powerful greenhouse gas.[22] In the US, only 15 percent of clothing and footwear is recycled; the remaining 85 percent ends up in a landfill or being incinerated.[23]

Transportation

Due to its world travels throughout its life cycle, our t-shirt generates significant greenhouse gas emissions. That is why the fashion industry is responsible for 10 percent of annual global carbon emissions.

Step 4: Map the key social impacts

Take another pass through your life cycle and this time, focus on the potential social impacts that might arise at each stage. People are needed to do all of the work along the life cycle and all of this work happens in the context of communities. For instance, you may want to consider the following topics:

Rights and wellbeing at work: including safe and healthy working conditions; respectful and inclusive workplace culture; respect for group rights and protections; healthy and inclusive workplace design; good health and wellbeing of workers; human dignity and integrity; decent work and work-life balance and adequate compensation (a living wage); right to organise; and family supports.

Rights and resilience in communities: including public safety and emergency services; respectful and inclusive communities; respect for Indigenous rights, sovereignty, and self-determination; access to healthy natural spaces; good health and wellbeing of community members; human dignity and integrity; local economic resilience and opportunities for decent local work; social and cultural connections and civil engagement; access to quality education, and development of knowledge and skills; access to clean water and sanitation, and efficient waste management; access

[22] de Freytas-Tamura, For Dignity and Development, East Africa Curbs Used Clothes Imports, https://www.nytimes.com/2017/10/12/world/africa/east-africa-rwanda-used-clothing.html
[23] Environmental Protection Agency, Facts and Figures about Materials, Waste and Recycling, https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling
[24] The World Bank, How Much Do Our Wardrobes Cost to the Environment? https://www.worldbank.org/en/news/feature/2019/09/23/costo-moda-medio-ambiente

to housing and land; affordable clean energy; inclusive banking, credit, and insurance; information, innovation, and telecommunication services; and transportation and mobility.

Governance and ethics: including respecting the rule of law; respecting traditional and community knowledge; reconciliation; fair distribution of resources, benefits, and opportunities; fair tax and royalty payments; fair and equitable dispute resolution; accessible and transparent grievance mechanisms; accountability, transparency and disclosure; anti-corruption and bribery; cybersecurity and data protection; and wealth disparity and excess compensation.

Let's take a look at some of the key social issues in the life cycle of a t-shirt.

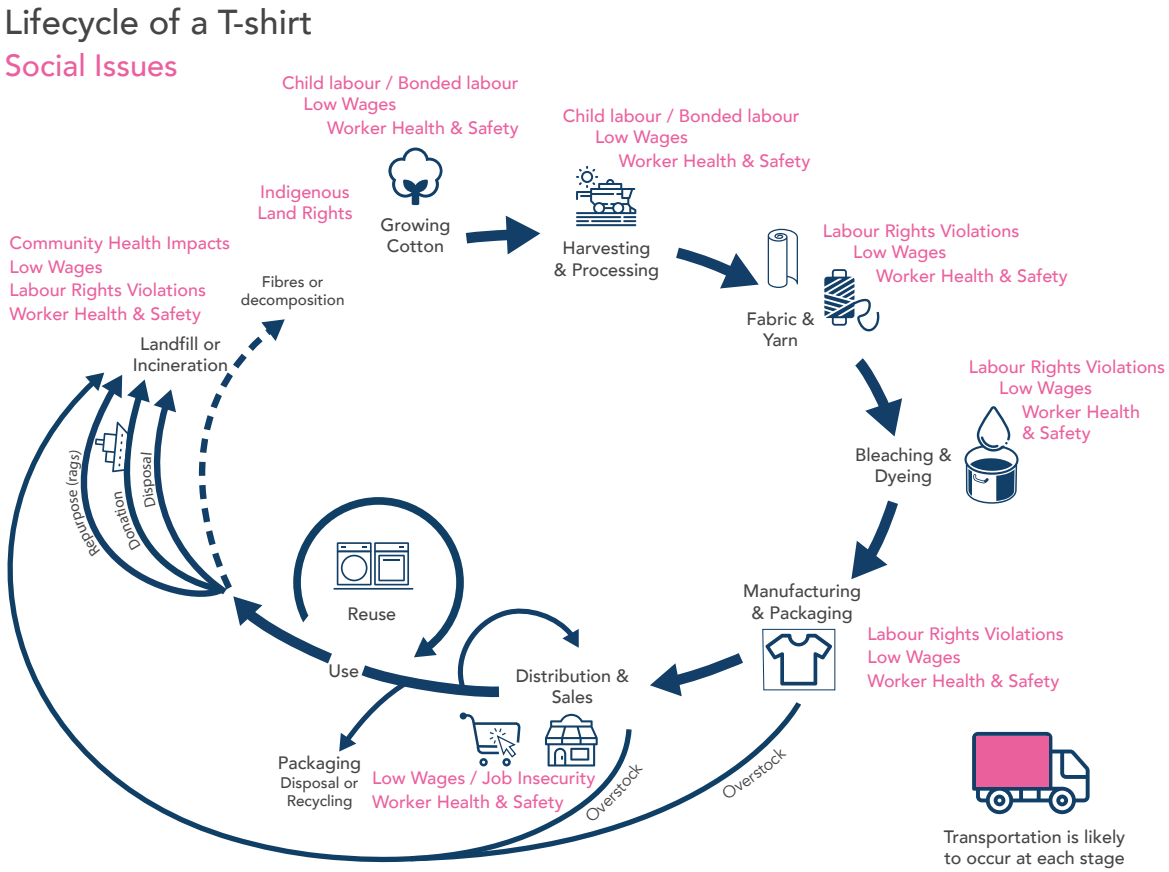


Figure 5: Life cycle of a t-shirt: social issues

Raw material extraction and processing

Much of the world's modern cotton industry has its roots in colonialism, the industrial revolution, and slavery. The industry has historically ignored issues around Indigenous rights and title, including control over land and resources.[25]

Currently more than 1 billion people worldwide depend on cotton for their livelihoods.[26] Poor working conditions, low wages, child labour, and forced labour are common in cotton production.[25] In India, where the cotton for our t-shirt is cultivated, smallholder farmers using labour-intensive manual processes are the main producers. Children, including an estimated 416,000 migrant child workers, may be involved in weeding, manual irrigation, and harvesting.[27] Farming families are often stuck in a cycle of poverty, with farming revenues unable to cover the cost of their basic food and healthcare needs on top of inputs for the farm; pesticides and fertilizers are costly and have adverse health impacts.[28] Smallholder farmers' low incomes are also constantly under threat from volatile cotton prices on the global market, which sometimes drop below production costs.[29] Crop failure, unreliable compensation, and unaffordable interest rates also contribute to high, even inescapable, indebtedness and sometimes result in child debt bondage.[30] Over 80% of farmer suicides in Punjab, India, between 2010 and 2013 were cotton growers[31] and 44 cotton farmers died by suicide each day in India in 2013.[32]

Harvested cotton is processed into bales at ginning factories. Child labour is known to occur in these factories in some countries, including in India. Health and safety conditions can be poor: workers often have no protective clothing or masks and air contaminated with dust and fibres may cause respiratory illness. Work accidents and injuries are common in ginning factories.[33]

---

[25] https://www.theatlantic.com/business/archive/2014/12/empire-of-cotton/383660/
[26] https://www.iisd.org/system/files/publications/ssi-global-market-report-cotton.pdf
[27] International Labour Organization. (2016) Child Labour in Cotton: a Briefing.
[28] https://textileexchange.org/2025-sustainable-cotton-challenge/
[29] https://sustainablecottonranking.org
[30] International Labour Organization. (2016) Child Labour in Cotton: A Briefing.
[31] https://www.tribuneindia.com/news/archive/features/80-of-farm-suicides-by-cotton-growers-study-373208
[32] https://www.cnn.com/2015/04/19/asia/india-cotton-farmers-suicide/index.html
[33] International Labour Organization. (2016) Child Labour in Cotton: A Briefing.

Component manufacturing, assembly, & packaging

Workers in textile mills and garment factories are predominantly women, who often work long hours in unsafe environments for low pay, sometimes in sweatshop conditions, so that manufacturers maintain low operating costs. Dyeing processes may expose workers to harmful chemicals, and garment production creates volatile fibres that affect workers' health when inhaled. Factories are not always purpose-built and safe: fires occur, and multiple factories have collapsed in the last decade, injuring and killing thousands of workers. Respect for labour rights is often lacking; workers report being denied maternity leave, retaliation against unionising employees, sexual harassment, forced overtime, and other abuses (the latter two under threat of job loss).[34] Not all manufacturers abuse rights to this extent, and many brands are paying more attention to these issues, but most fashion brands still have limited visibility into the adverse social impacts in their value chains.

Mills and factories across the world frequently employ migrant workers, who may not be able to see their families for extended periods of time, especially if they must pay off debts to brokers and traffickers. Legal and illegal migrant workers are vulnerable to employer mistreatment under threat of dismissal, loss of legal status, arrest, and deportation.[35] Additionally, when migrant workers rather than locals get jobs at a nearby factory, it can be a source of tension in communities.

Distribution and sale

Low pay and job insecurity for workers also extends into the retail distribution chain. Distribution centre workers may be exposed to unsafe and unhealthy working conditions, including risk of injury, and often work long shifts for low compensation, with limited job security. Similarly, low-skilled retail jobs often provide workers with low compensation and limited job security, in addition to unpredictable schedules, with negative implications for worker wellbeing.

[34] Human Rights Watch (2018) https://www.hrw.org/world-report/2018/country-chapters/global#
[35] Clean Clothes Campaign. https://cleanclothes.org/issues/migrants

Disassembly, repurposing, recycling, composting, incineration, or landfilling

At end-of life, most clothes are landfilled. Community health can be adversely impacted by groundwater contamination and toxic leachate from the break-down of textiles in neighbouring landfills. However, donating clothes can have unexpected consequences too: many are exported to the developing world where some are resold, which can depress local textile and clothing production and markets, and overwhelm them.[36] With the rise of fast fashion, most of this clothing is often of such poor quality that it has no resale value. Instead, it overwhelms local infrastructure and gets dumped and left to decay, endangering precious community water systems.

Step 5: Identify potential system interventions.

This time, as you pass through your product life cycle, try to identify potential system interventions to address the environmental and social issues that you surfaced in the last two steps. These social and environmental issues may be part of interconnected deeply rooted systems challenges, in which case no one company alone will be able to tackle them. Instead, systems challenges require a systems lens and call for a multi-stakeholder approach. You will need to identify which peers, which value chain partners, and which civil society organisations, government bodies, and impacted communities or regions may have a shared interest in addressing these issues and think about how you could engage them in the co-design of system interventions.

From the very beginning, choices that a company makes at the design stage directly affect not only how their product will function, but also how it will impact the environment and society as it is manufactured, used, and disposed of, recycled, or repurposed.

[36] Schlossburg, Inconspicuous Consumption: The Environmental Impact You Don't Know You Have

For instance, you may want to consider doing the following:

- Rethink how to provide the same benefit or function with reduced adverse impacts;
- Reduce impacts from your raw materials by substituting materials or changing how they are produced;
- Improve your manufacturing processes to ensure worker safety, treat workers with dignity, reduce energy and water use, reduce waste, and reuse by-products;
- Reduce your distribution impacts by regionalising and re-localising production, reducing packaging, reducing product and packaging weight, and developing reusable packaging systems;
- Reduce impacts during customer use by encouraging lower consumption, reducing impacts of use and maintenance, improving longevity and designing for and enabling repair and upgrading;
- Optimise the end-of-life phase by making products upgradeable, designing for disassembly, and designing systems to recover key materials and components.

A useful tool for helping to brainstorm strategies to address environmental impacts is the Okala Ecodesign Strategy Wheel which clusters potential strategies according to the stages of the life cycle of a product.[37]

[37] Okala, 2014 Okala Practitioner Guide, http://www.okala.net

Here are some of the possible strategies that might improve the life cycle impacts of a t-shirt:

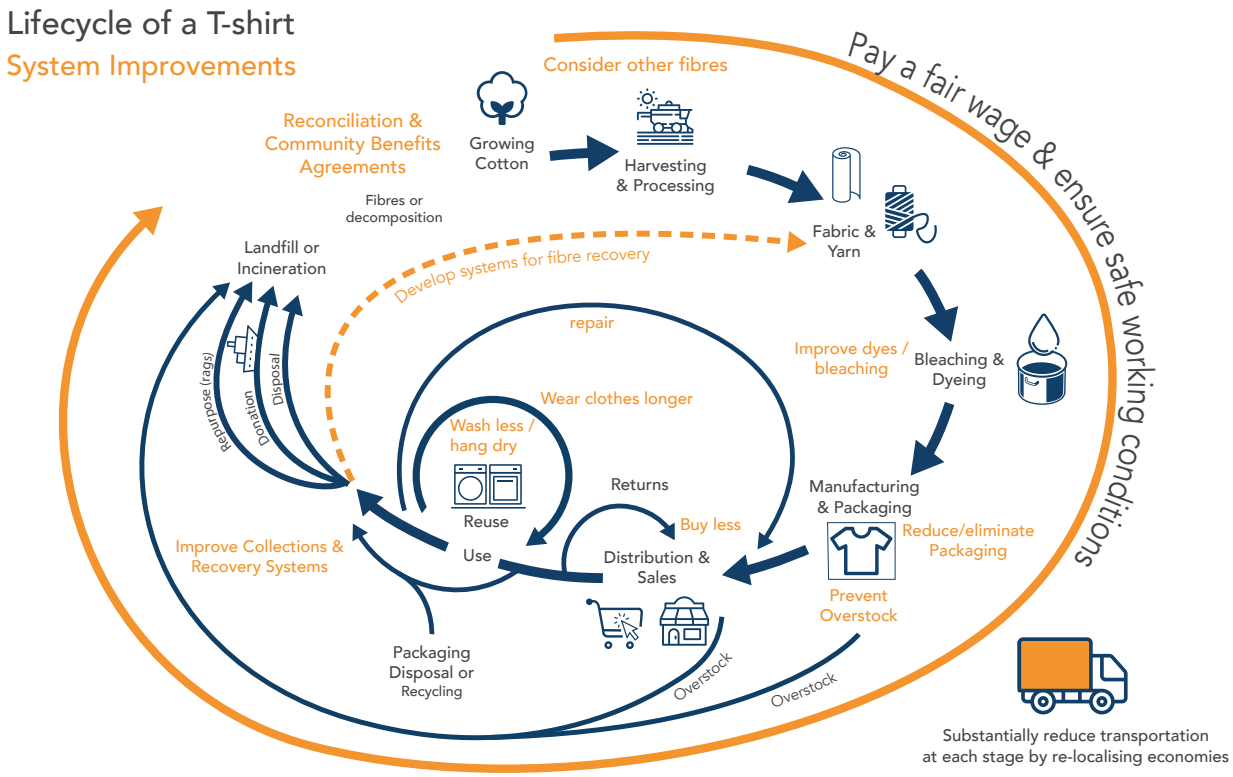


Figure 6: Life cycle of a t-shirt: Potential system improvements

Pay a fair wage and ensure safe working conditions.

Pay to workers currently represents less than one percent of the cost of producing a t-shirt.[38] Brands need to ensure that all workers in their supply chain earn a living wage and have safe working conditions and reasonable working hours.

Negotiate reconciliation and community benefit / community management agreements.

Though not yet common in apparel, other industries like mining and agriculture have been negotiating benefit sharing agreements with communities. For instance, for centuries the Khoi and San, collectively known as the Khoisan, have lived in the lands near the Cederburg Mountains in South Africa. This region is the only place in the world where drinkable cultivars of the rooibos bush thrive, which are used to make

[38] Clean Clothes Campaign, Poverty Wages, https://cleanclothes.org/poverty-wages

rooibos tea. A landmark agreement under the United Nations' Nagoya Protocol has awarded these Indigenous Peoples benefits from the harvest and marketing of rooibos tea. The San and Khoi will receive 1.5 percent of the farmgate price of unprocessed rooibos, split 50:50. In addition, companies that use the likeness and symbols of Khoisan to market their products will need to pay royalties.[39]

Improve the bleaching and dyeing processes.

The fashion industry is working to develop more sustainable dyeing processes that require no water, and using dyes that are free of free of halogens and heavy metals and even those that create no effluents at all.[40]

Change product packaging.

To reduce plastic waste, the fashion industry is starting to move away from the use of polybags as the preferred product packaging during distribution. Mountain Equipment Co-op stopped using polybag packaging in 2010, and ships items only with a single plastic carton liner to protect its apparel from moisture damage in transit by rolling each item into a "sushi roll" and tying them with raffia or just packing them loosely.[41]

Reduce overstock.

Companies will need to rethink their production cycles to reduce overstock.

Help shift consumer behaviour.

Companies like Patagonia and REI have been encouraging their customers to buy less, wear clothes longer, wash them less, and return them for refurbishing, even creating secondary markets for previously loved goods.[42] Some other companies have started offering the services of a tailor to provide free minor repairs to clothing that is otherwise still usable.

---

[39] Bolton, Historic Agreement Requires Tea Industry to Share Rooibos Revenue with Indigenous Tribes, https://worldteanews.com/tea-industry-news-and-features/historic-agreement-requires-tea-industry-to-share-rooibos-revenue-with-indigenous-tribes
[40] Vermandel, Dyeing needs to be sustainable, https://www.fibre2fashion.com/industry-article/7752/dyeing-needs-to-be-sustainable
[41] MEC, Packaging & Transportation, https://www.mec.ca/en/explore/packaging-and-transportation
[42] Patagonia, Worn Wear is Patagonia's hub for keeping gear in play, https://wornwear.patagonia.com

Use recovered fibres.

The industry is starting to experiment with improving retail and municipal collection systems and considering using fibres that are more readily recycled.[43] Companies are also trying to avoid mixing fibres so that they can be more easily recovered and recycled.

Step 6: Prioritise and develop an action plan.

Now it is time to prioritise. There is a limit to the resources that any company can spend. You will need to start by thinking about the work required before these strategies could be adopted. For instance, you may need to undertake more research on the nature and extent of your impacts, understand what alternatives might be available, and/or estimate the costs and availability of resources and expertise to make a shift.

You will also need to gauge your ability to influence change. Which of these systems interventions can you lead directly, and for which would you need to rely on your indirect influence with others in the value chain, or in your industry.

There is no 'one best way' to prioritise in a conceptual life cycle mapping exercise. Here are some factors that you may want to consider:

- Where could we make the biggest impact?
- What is in our direct control?
- Where do we have influence?
- Which issues present a reputational risk to our business?
- Where could we differentiate our product?
- What can be done easily, and what would require longer term investments?
- What information do we need to proceed?

At this stage, you will need to decide which factors you will use to guide your decision-making and identify a set of initiatives to prioritise in the short term. For instance, you could focus on the areas where you have the greatest impact, the areas in which you have the most control to make changes, or the areas which present the greatest risks to your business. You could choose to undertake other initiatives at a later stage, as resources become available. The key at this point is to be clear on the rationale that you used in guiding your decision.

[43] Recover, A Circular System, https://www.recovertex.com/system/

For our study of a t-shirt, we have prioritised the systems interventions that are the most likely to yield significant positive changes in environmental and social outcomes.

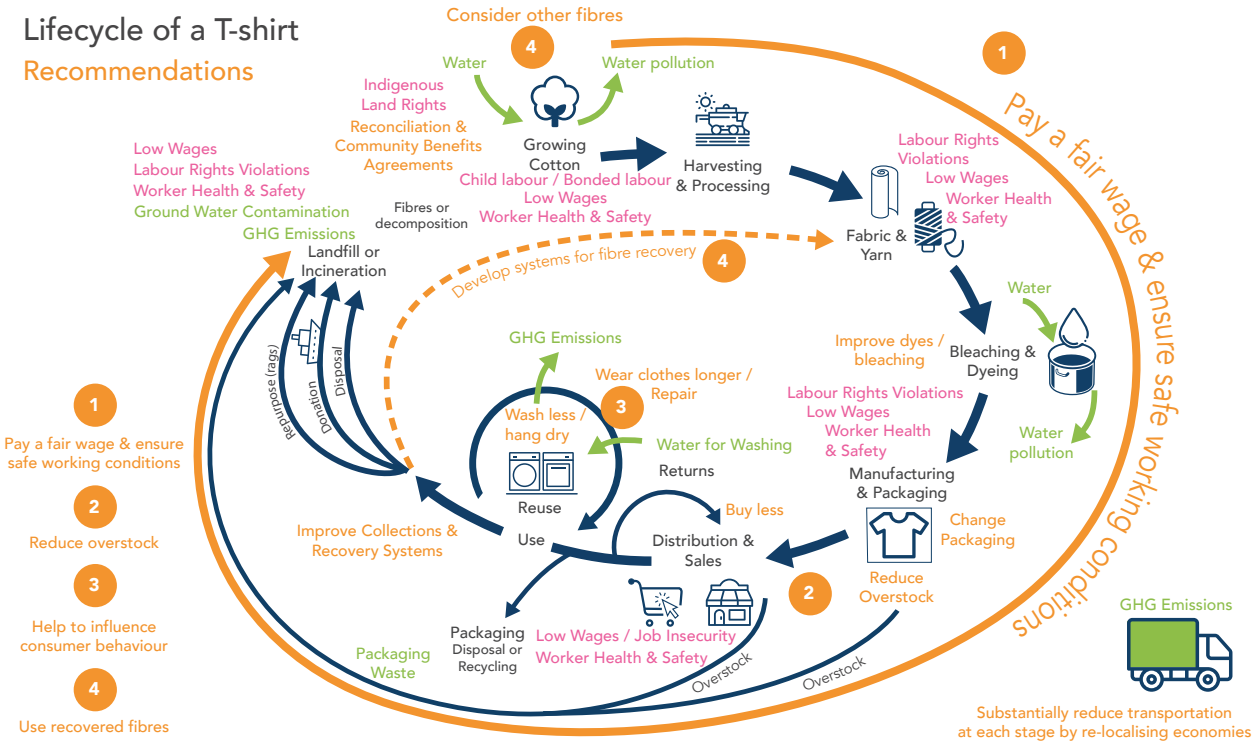


Figure 7: Life cycle of a t-shirt: recommendations

	STRATEGY	NEXT STEPS
1	Pay a fair wage and ensure safe working conditions	• Develop a public position on worker wellbeing. • Conduct human rights and worker safety impact assessments across your supply chain. • Undertake living wage assessments. • Collaborate with suppliers to ensure a living wage and protect worker wellbeing.
2	Reduce overstock	• Explore how to improve forecasting and how to reconfigure ordering processes to minimise overstock.
3	Help to influence consumer behaviour	• Develop campaigns and systems to encourage consumers to buy less, wear longer, wash less frequently and at lower temperatures, and repair or return their clothing for fibre recovery.
4	Use recovered fibres	• Explore alternative materials that are more readily recycled and how to shift to a more circular production system.

Step 7: Create a summary report.

To help others understand what you have learned from your conceptual life cycle mapping exercise, consider preparing a short summary report. This report could outline the key environmental and social aspects of this product's full life cycle, advance a rationale for why some issues should be prioritised over others, and make recommendations for how to improve the overall life cycle.

Remember, this is conceptual. The focus is on identifying potential impacts, understanding what needs to be further investigated, and getting a sense of what to do next to put your company on a solid path to improve the sustainability of your product, process, or service. It is not necessary to conduct detailed calculations at this stage. But, if you come across useful resources or key metrics, go ahead and include them to illustrate key choices along the life cycle. It is important to provide some kind of rationale for why you are prioritising some issues and some systems interventions above others.

When dealing with complex systems, images and system maps are incredibly useful ways of conveying complex information concisely and in an approachable way. Include a drawing of the life cycle of the product in which you identify key stages, the most material inputs and outputs, and/or issues at each stage and make recommendations for next steps for improving the sustainability of the product.

Ideally, your diagram should stand on its own as a summary of the key findings of the report. It should be easy to distinguish the key stages in the life cycle and key environmental and social issues at each stage. You will also want to point to key recommendations that would help to address these most important issues.

Keep your report short and consider pushing more detailed information into appendices. For instance, you will likely want to create an appendix that describes the key stages of the life cycle and others that describe what you have learned about the key social and environmental issues that arise throughout the life cycle.

Finally, be sure to include a clear 'ask' or set of recommended actions. What decision are you seeking from the executive team? What resources and mandate do you need to move forward? These could be a study, a pilot project, reaching out to supply chain partners, or any other 'next steps' that you think are appropriate.

Life cycle mapping for services or processes

We have taken you through the process of mapping the life cycle of a product above, but you can apply a similar approach to map the life cycle of a service or even a process.

To illustrate this, let's think about a company that offers a wilderness safari experience. The functional unit was set as one night's stay including transportation to/from the airport, one night of accommodation, food, use of the amenities at the wilderness lodge, and safari services.

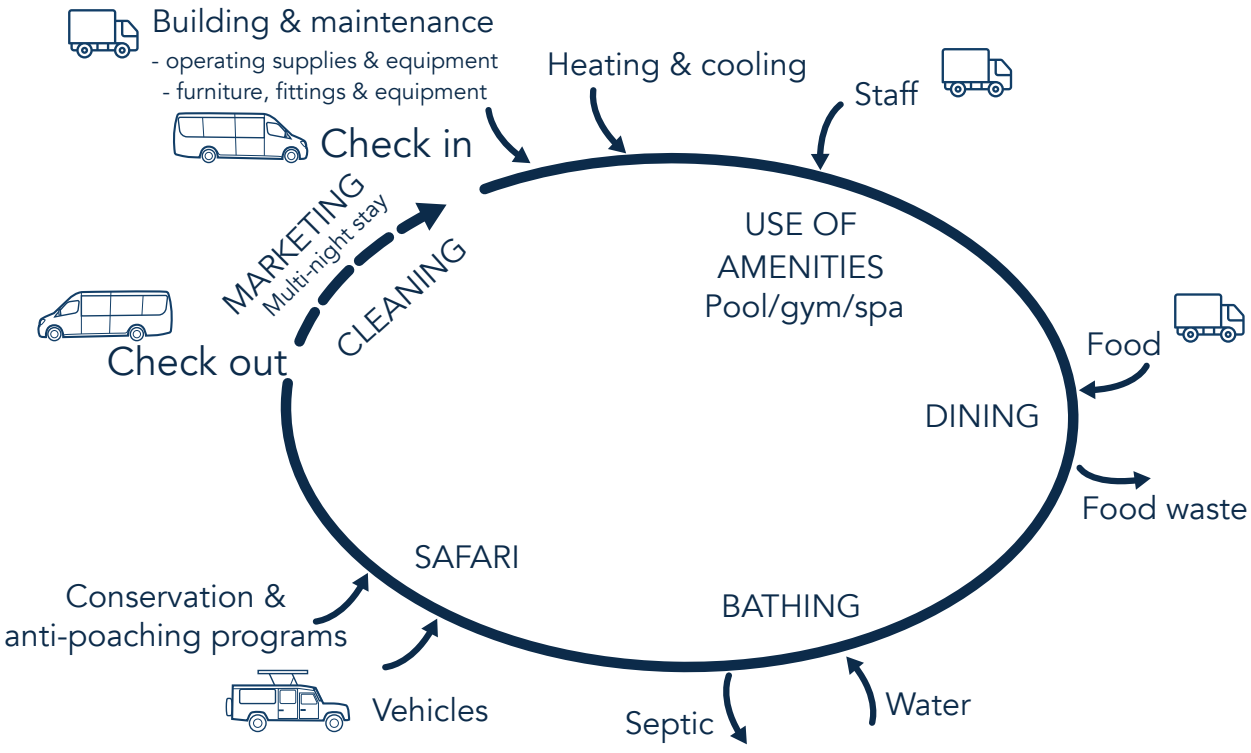


Figure 8: Life cycle of one night's stay at wilderness lodge

Customers will arrive at the airport and be transported to the lodge. They will check in and may make use of the onsite amenities before dinner. They will sleep and bathe and have breakfast the next morning. They will then head out on safari. The room will be cleaned, the sheets and towels washed and replaced and at the end of their stay, they will be transported back to the airport. Of course, the marketing team plays a role in getting them to come to your lodge in the first place.

Along the way, you will need to think about building construction and operation and maintenance; heating and cooling; staff; food and food waste; water and septic; safari vehicles; data collection, storage, and protection, and the conservation and anti-poaching work needed to tend to your concession …and let's not forget the transportation required to enable all of this.

Similar to the process that we outlined for a t-shirt, the next step would be to think about the social and environmental implications at each of these steps and to begin to look for opportunities to make improvements.

More resources

For more resources on life cycle thinking or on helping companies to embed sustainability into their operations and decision-making, visit us at www.embeddingproject.org.

Acknowledgements

The Embedding Project is hosted by the Beedie School of Business at Simon Fraser University.

This research was supported by the Social Sciences and Humanities Research Council of Canada

Social Sciences and Humanities Research Council of Canada
Conseil de recherches en sciences humaines du Canada
Canada

and contributions from our partner companies:

https://www.embeddingproject.org/our-community

Embedding PROJECT