

## Review Article

### Understanding the importance of sustainable fashion

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## 1 Introduction

The pandemic slowed fast fashion to a standstill. Now as the world opens up and we are socializing and going places, we want to dress up again. But after living a confined and simpler life during COVID, this is a good time to take stock of the implications of how we dress. Fashion, and especially fast fashion, has enormous environmental impacts on our planet, as well as social ones.



Since the 2000s, fashion production has doubled and it will likely triple by 2050, according to the American Chemical Society. The production of polyester, used for much cheap fast fashion, as well as athleisure wear, has increased nine-fold in the last 50 years. Because clothing has gotten so cheap, it is easily discarded after being worn only a few times. One survey found that 20 percent of clothing in the US is never worn; in the UK, it is 50 percent. Online shopping, available day and night, has made impulse buying and returning items easier.



According to McKinsey, average consumers buy 60 percent more than they did in 2000, and keep it half as long. And in 2017, it was estimated that 41 percent of young women felt the need to wear something different whenever they left the house. In response, there are companies that send consumers a box of new clothes every month.

### **Fashion's environmental impacts**

Fashion is responsible for 10 percent of human-caused greenhouse gas emissions and 20 percent of global wastewater, and uses more energy than the aviation and shipping sectors combined.

### **Impacts on water**

Global fashion also consumes 93 billion metric tons of clean water each year, about half of what Americans drink annually.

Cotton is an especially thirsty crop. For example, one kilogram of cotton used to produce a pair of jeans can consume 7,500 to 10,000 liters of water—the amount a person would drink over 10 years. Cotton production also requires pesticides and insecticides, which pollute the soil; runoff from fertilized cotton fields carry the excess nutrients to water bodies, causing eutrophication and algal blooms.

The dyeing process for fabrics, which uses toxic chemicals, is responsible for 17 to 20 percent of global industrial water pollution.



### **Contributions to climate change**

To feed the fashion industry's need for wood pulp to make fabrics like rayon, viscose and other fabrics, 70 million tons of trees are cut down each year. That number is expected to double by 2034, speeding deforestation in some of the world's endangered forests.

The fashion industry produces 1.2 million metric tons of CO<sub>2</sub> each year, according to a [MacArthur Foundation study](#). In 2018, it resulted in more greenhouse gas emissions than the carbon produced by France, Germany and the UK all together. Polyester, which is actually plastic made from fossil fuels, is used for about 65 percent of all clothing, and consumes 70 million barrels of oil each year. In addition, the fashion industry uses large amounts of fossil fuel-based plastic for packaging and hangers.

### **Waste**

Less than one percent of clothing is recycled to make new clothes. The fibers in clothing are polymers, long chains of chemically linked molecules. Washing and wearing clothing shorten and weaken these polymers, so by the time a garment is discarded, the polymers are too short to turn into a strong new fabric. In addition, most of today's textile-to-textile recycling technologies cannot separate out dyes, contaminants, or even a combination of fabrics such as polyester and cotton.

As a result, 53 million metric tons of discarded clothing are incinerated or go to landfills each year. In 2017, Burberry burned \$37 million worth of unsold bags, clothes and perfume. If sent to a landfill, clothes made from natural fabrics like cotton and linen may degrade in weeks to months, but synthetic fabrics can take up to 200 years to break down. And as they do, they produce methane, a powerful global warming greenhouse gas.

### **Microplastic pollution**

Many people have lived solely in athleisure wear during the pandemic, but the problem with this is that the stretch and breathability in most athleisure comes from the use of synthetic plastic fibers like polyester, nylon, acrylic, spandex and others, which are made of plastic.

When clothes made from synthetics are washed, microplastics from their fibers are shed into the wastewater. Some of it is filtered out at wastewater treatment plants along with human

waste and the resulting sludge is used as fertilizer for agriculture. Microplastics then enter the soil and become part of the food chain. The microplastics that elude the treatment plant end up in rivers and oceans, and in the atmosphere when seawater droplets carry them into the air. It's estimated that 35 percent of the microplastics in the ocean come from the fashion industry. While some brands use "recycled polyester" from PET bottles, which emits 50 to 25 percent fewer emissions than virgin polyester, effective polyester recycling is limited, so after use, these garments still usually end up in the landfill where they can shed microfibers.

Microplastics harm marine life, as well as birds and turtles. They have already been found in our food, water and air—one study found that Americans eat 74,000 microplastic particles each year. And while there is growing concern about this, the risks to human health are still not well understood.

### **Fashion's social impacts**

Because it must be cheap, fast fashion is dependent on the exploited labor force in developing countries where regulations are lax. Workers are underpaid, overworked, and exposed to dangerous conditions or health hazards; many are underage.

Of the 75 million factory workers around the world, it's estimated that only two percent earn a living wage. To keep brands from moving to another country or region with lower costs, factories limit wages and are disinclined to spend money to improve working conditions. Moreover, workers often live in areas with waterways polluted by the chemicals from textile dyeing.

### **How can fashion be more sustainable?**

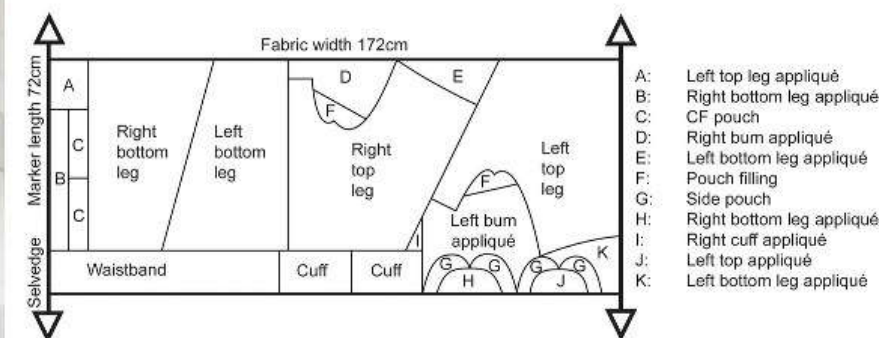
As opposed to our current linear model of fashion production with environmental impacts at every stage, where resources are consumed, turned into a product, then discarded, sustainable fashion minimizes its environmental impact, and even aims to benefit the environment. The goal is a circular fashion industry where waste and pollution are eliminated, and materials are used for as long as possible, then reused for new products to avoid the need to exploit virgin resources.

Many designers, brands, and scientists — including students in Columbia University's Environmental Science and Policy program— are exploring ways to make fashion more sustainable and circular.

### **Less waste**

Since 80 to 90 percent of the sustainability of a clothing item is determined by decisions made during its design stage, new strategies can do away with waste from the get-go.

To eliminate the 15 percent of a fabric that usually ends up on the cutting room floor in the making of a garment, zero waste pattern cutting is used to arrange pattern pieces on fabric like a Tetris puzzle.



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Designer YeohLee is known as a zero waste pioneer, employing geometric concepts in order to use every inch of fabric; she also creates garments with the leftovers of other pieces. Draping and knitting are also methods of designing without waste.

3D virtual sampling can eliminate the need for physical samples of material. A finished garment can sometimes require up to 20 samples. The Fabricant, a digital fashion house, replaces actual garments with digital samples in the design and development stage and claims this can reduce a brand’s carbon footprint by 30 percent.

Some clothing can be designed to be taken apart at the end of its life; designing for disassembly makes it easier for the parts to be recycled or upcycled into another garment. To be multifunctional, other garments are reversible, or designed so that parts can be subtracted or added. London-based brand Petit Pli makes children’s clothing from a single recycled fabric, making it easier to recycle; and the garments incorporate pleats that stretch so that kids can continue to wear them as they grow.

3D printing can be used to work out details digitally before production, minimizing trial and error; and because it can produce custom-fit garments on demand, it reduces waste. In addition, recycled materials such as plastic and metal can be 3D printed.

Sustainable designer Iris Ven Herpen is known for her fabulous 3D printed creations, some using upcycled marine debris; she is also currently working with scientists to develop sustainable textiles.

DyeCoo, a Dutch company, has developed a dyeing technique that uses waste CO2 in place of water and chemicals. The technology pressurizes CO2 so that it becomes supercritical and allows dye to readily dissolve, so it can enter easily into fabrics. Since the process uses no water, it produces no wastewater, and requires no drying time because the dyed fabric comes out dry. Ninety-five percent of the CO2 is recaptured and reused, so the process is a closed-loop system.

Heuritech, a French startup, is using artificial intelligence to analyze product images from Instagram and Weibo and predict trends. Adidas, Lee, Wrangler and other brands have used it to anticipate future demand and plan their production accordingly to reduce waste.

Mobile body scanning can help brands produce garments that fit a variety of body types instead of using standard sizes. 3D technology is also being used for virtual dressing, which will enable consumers to see how a garment looks on them before they purchase it. These innovations could lead to fewer returns of clothing.

Another way to reduce waste is to eliminate inventory. On-demand product fulfillment companies like Printful enable designers to sync their custom designs to the company's clothing products. Garments are not created until an order comes in.

For Days, a closed-loop system, gives swap credits for every article of clothing you buy; customers can use swap credits to get new clothing items, all made from organic cotton or recycled materials. The swap credits encourage consumers to send in unwanted For Days clothes, keep them out of the landfill, and allow them to be made into new materials. Customers can also earn swap credits by filling one of the company's Take Back bags with any old clothes, in any condition, and sending it in; these are then resold if salvageable or recycled as rags.

But perhaps the least wasteful strategy enables consumers not to buy any clothes at all. If they are mainly concerned about their image on social media, they can use digital clothing that is superimposed over their image. The Fabricant, which creates these digital garments, aims to make "self expression through digital clothing a sustainable way to explore personal identity."

### **Better materials**

Many brands are using textiles made from natural materials such as hemp, ramie or bamboo instead of cotton. Bamboo has been touted as a sustainable fabric because it is fast-growing and doesn't require much water or pesticides; however, some old growth forests are being cut down to make way for bamboo plantations. Moreover, to make most bamboo fabrics soft, they are subjected to chemical processing whose toxins can harm the environment and human health.

Because of this processing, the Global Organic Textile Standard says that almost all bamboo fiber can "not be considered as natural or even organic fibre, even if the bamboo plant was certified organic on the field."

Some designers are turning to organic cotton, which is grown without toxic chemicals. But because organic cotton yields are 30 percent less than conventional cotton, they need 30 percent more water and land to produce the same amount as conventional cotton. Other brands, such as North Face and Patagonia, are creating clothing made from regenerative cotton—cotton grown without pesticides, fertilizers, weed pulling or tilling, and with cover crops and diverse plants to enhance the soil.

Textiles are also being made with fibers from agriculture waste, such as leaves and rinds. Orange Fiber, an Italian company, is using nanotechnology to make a sustainable silky material by processing the cellulose of oranges. H&M is using cupro, a material made from cotton waste. Flocus makes fully biodegradable and recyclable yarns and fabrics from the fibers of



kapok tree pods through a process that doesn't harm the trees. Kapok trees can grow in poor soils without much need for water or pesticides.

In 2016, Theanne Schiros, a principal investigator at Columbia University's Materials Research Science and Engineering Center and assistant professor at the Fashion Institute of Technology (FIT), mentored a group of FIT students who created a bio-design award-winning material from algae. Kelp, its main ingredient, is fast growing, absorbs CO<sub>2</sub> and nitrogen from agricultural runoff, and helps increase biodiversity. With the help of Columbia University's Helen Lu, a biomedical engineer, the team created a bio-yarn they called AlgiKnit. Having received over \$2 million in initial seed funding, the start-up, based in Brooklyn, is scaling up for market entry.

Schiro and Lu also developed a microbial biolather. The compostable material consists of a nanocellulose mesh made through a fermentation process using a culture of bacteria and yeast. Schiros explained that these bacteria produce cellulose nanofibers as part of their metabolism; the bacteria were used in the fermentation of kombucha as early as 220 BC in what was Manchuria and in vinegar fermentation as early as 5,000 BC in Egypt. Biofabrication of the material is 10,000 times less toxic to humans than chrome-tanned leather, with an 88 to 97 percent smaller carbon footprint than synthetic (polyurethane) leather or other plastic-based leather alternatives. The fabrication process also drew on ancient textile techniques for tanning and dyeing. Schiros worked with the designers of Public School NY on Slow Factory's One x One Conscious Design Initiative challenge to create zero-waste, naturally dyed sneakers from the material.

Schiro is also co-founder and CEO of the startup Werewool, another collaboration with Lu, and with Allie Obermeyer of Columbia University Chemical Engineering. Werewool, which was recognized by the 2020 Global Change Award, creates biodegradable textiles with color and other attributes found in nature using synthetic biology. "Nature has evolved a genetic code to make proteins that do things like have bright color, stretch, moisture management, wicking, UV protection—all the things that you really want for performance textiles, but that currently come at a really high environmental cost," said Schiros. "But nature accomplishes all this and that's attributed to microscopic protein structures."

Werewool engineers proteins inspired by those found in coral, jellyfish, oysters, and cow milk that result in color, moisture management or stretch. The DNA code for those proteins is inserted into bacteria, which ferment and mass-produce the protein that then becomes the basis for a fiber. The company will eventually provide its technology and fibers to other companies throughout the supply chain and will likely begin with limited edition designer brands.

### **Better working conditions**

There are companies now intent on improving working conditions for textile workers. Dorsu in Cambodia creates clothing from fabric discarded by garment factories. Workers are paid a living wage, have contracts, are given breaks, and also get bonuses, overtime pay, insurance and paid leave for sickness and holidays.

Mayamiko is a 100 percent PETA-certified vegan brand that advocates for labor rights and created the Mayamiko Trust to train disadvantaged women.

Workers who make Ethcs' PETA-certified vegan garments are protected under the Fair Wear Foundation, which ensures a fair living wage, safe working conditions and legal labor contracts for workers. The Fair Wear Foundation website lists 128 brands it works with.

### **Beyond sustainability**

Schiros maintains that making materials in collaboration with traditional artisans and Indigenous communities can produce results that address environmental, social and economic facets of sustainability. She led a series of natural dye workshops with women tie dyers in Kindia, Guinea, and artisans in Grand-Bassam, Côte d'Ivoire, and collaborated with New York designers to make a zero-waste collection from the fabrics created. The project connected FIT faculty and students to over 300 artisans in West Africa to create models for inclusive, sustainable development through textile arts, education, and entrepreneurship.

Partnering with frontline communities that are protecting, for example, the Amazon rainforest, does more than simply sustain—it protects biodiversity and areas that are sequestering carbon. “So with high value products that incorporate fair trade and clear partnerships into the supply chain, you not only have natural, biodegradable materials, but you have the added bonus of all that biodiversity that those communities are protecting,” she said. “Indigenous communities are five percent of the global population, and they’re protecting 80 percent of the biodiversity in the world...Integrating how we make our materials, our systems and the communities that are sequestering carbon while protecting biodiversity is critically important.”

### **The need for transparency**

In order to ensure fashion's sustainability and achieve a circular fashion industry, it must be possible to track all the elements of a product from the materials used, chemicals added, production practices, and product use, to the end of life, as well as the social and environmental conditions under which it was made.

Blockchain technology can do this by recording each phase of a garment's life in a decentralized tamper-proof common ledger. Designer Martine Jarlgaard partnered with blockchain tech company Provenance to create QR codes that, when scanned, show the garment's whole history. The software platform Eon has also developed a way to give each garment its own digital fingerprint called Circular ID. It uses a digital identifier embedded in the clothing that enables it to be traced for its whole lifecycle.

Transparency is also important because it enables consumers to identify greenwashing when they encounter it. Greenwashing is when companies intentionally deceive consumers or oversell their efforts to be sustainable.

Amendi, a sustainable fashion brand focusing on transparency and traceability, co-founded by Columbia University alumnus Corey Spencer, has begun a campaign to get the Federal Trade Commission to update its Green Guides, which outline the principles for the use of green claims. When the most recent versions of the Green Guides were released in 2012, they did not



scrutinize the use of “sustainability” and “organic” in marketing. The use of these terms has exploded since then and unless regulated, could become meaningless or misleading.

## Conclusion

The key to making fashion sustainable is the consumer. If we want the fashion industry to adopt more sustainable practices, then as shoppers, we need to care about how clothing is made and where it comes from, and demonstrate these concerns through what we buy. The market will then respond.

We can also reduce waste through how we care for our clothing and how we discard it.

Here are some tips on how to be a responsible consumer:

- Buy only what you need
- Buy from sustainable brands with transparent supply chains
  - Look for sustainable certification from the Fairtrade Foundation, Global Organic Textiles Standard, Soil Association, and Fair Wear Foundation
  - Check the Fashion Transparency Index to see how a company ranks in transparency.
- Learn how to shop for quality and invest in higher-quality clothing
- Choose natural fibers and single fiber garments
- Wear clothing for longer
- Take care of clothing: wash items less often, repair them so they last. Patagonia operates Worn Wear, a recycling and repair program.
- Upcycle your unwanted clothes into something new
- Buy secondhand or vintage; sell your old clothes at Thred Up, Poshmark, or the Real Real.
- When discarding, pass clothing on to someone who will wear it, or to a thrift shop
- Rent clothing from Rent the Runway, Armoire or Nuuly

## References

1. Sociedade, E.C. The evolution and democratization of modern fashion: From Frederick Worth to Karl Lagerfeld's fast fashion. *Res. J. Costume Cult.* 2013, 24, 79-94.
2. Aus, R. Trash to Trend-Using Upcycling in Fashion Design. Ph.D. Thesis, Estonian Academy of Arts, Tallinn, Estonia, 2011.
3. Breward, C. *The Culture of Fashion*, 1st ed.; Manchester University Press: Manchester, UK, 1995; p. 5.
4. Kyoto Costume Institute. *Fashion: A History from the 18th to the 20th Century*, 1st ed.; TASCHEN: Cologne, Germany, 2002.
5. ThredUP. How Dirty Is Your Closet? Introducing Thredup's Fashion Footprint Calculator.
6. UK Parliament. *Fixing Fashion: Clothing Consumption and Sustainability: Sixteenth Report of Session 2017-2019*. National House of Commons 2019.

7. Cline, E. *The Councious Closet*; Plume: New York, NY, USA; Penguin Portfolio: London, UK, 2019; pp. 22-30.
8. Linden, A.R. *An Analysis of the Fast Fashion Industry*. Bard Undergraduate Senior Projects 2016.
9. Ütebay, B.; Çelik, P.; Çay, A. *Textile Industry and Waste*, 3rd ed.; Open Access Books: London, UK, 2020; pp. 1-19.
10. Waddell, G. *How Fashion Works: Couture, Ready-to-Wear and Mass Production*; John Wiley & Sons: Hoboken, NJ, USA, 2013.