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Fashioning a circular future for traditional and alternative leather

by Sean Mowbray on 6 February 2024

- *Crafting leather from animal hides is an age-old industry, but its production today continues to mostly follow a linear model often mired in a range of environmental problems, including pollution, the creation of huge amounts of waste, high water use, and climate change-causing emissions.*
- *Applying cleaner and circular economy-based solutions to the leather industry is needed to change this paradigm and make the supply chain more environmentally friendly, say experts. Some companies are heading down this path, but efforts to roll out such solutions globally to all producer nations face a host of barriers.*
- *Some companies see the future of a sustainable leather industry in synthetic and biobased alternatives, using a smorgasbord of waste agricultural materials and more in the place of animal hides and plastics. But these alternatives, too, come with their own sustainability challenges or questions of scalability.*
- *Above all, experts say, achieving viable long-term circular solutions for the leather industry will require a diverse range of sustainable supply chain and production innovations, including the use of alternative materials.*

largely followed a linear "take-make-waste" production model, with unsustainable tanning through finishing processes dependent on chromium salts and other polluting toxins, and requiring massive amounts of water.

Today, as the industry edges slowly toward circular principles, traditional leather products are being forced to compete with all manner of synthetics (some fossil fuel-derived), and others biobased (derived from sources as diverse as cacti and bananas, but often requiring plastic additives to achieve traditional leather's durability). No matter: leather in all its forms remains a growth industry (<https://www.fortunebusinessinsights.com/leather-goods-market-104405>). In 2023, it was valued at \$460 billion globally, and expected to hit \$700 billion in worth by 2030 as demand surges and the range of synthetic alternatives expands.

Against this booming backdrop, critics argue that using skins provided by the global livestock industry is responsible for a litany of environmental supply chain problems, starting on ranches, moving through tanneries, and extending to leather's end of life.

Still, experts hold out hope that innovative circular solutions (<https://www.sciencedirect.com/science/article/abs/pii/S0959652619346074>) could create a far more sustainable traditional leather industry. Meanwhile, all manner of alternatives could lessen environmental harm, though these substitutes could come with their own cost, scaling, technical and environmental conundrums.



Leather production occurs around the globe. Experts say that the industry is changing and improving its environmental standards. Managing massive amounts of leather waste is a huge challenge. "If you consider the end-of-life leather — that comes from shoes, from apparel, from cars — they're usually contaminated with lots of chemicals. You need to consider how you separate these, and the locally available options are often very limited," says Shahin Rahimifard, an industrial engineer and professor at the U.K.'s Loughborough University. Image by Oleg via Pixabay (Public domain).

The limits of traditional leather's circularity claims

Leather advocates contend that products derived from livestock skins are inherently circular, turning meat industry "waste" into a valuable fashion commodity. Industry representatives even point to tanning as one of the oldest examples of "upcycling," or creative reuse, a pillar of the circular economy (<https://news.mongabay.com/2023/07/the-circular-economy-sustainable-solutions-to-solve-planetary-overshoot/>). Without leather production, they argue, many thousands of unutilized tons of hide would end up in landfills or incinerated.

"The majority of life-cycle assessment studies on leather production and use assume positive impact mainly because you are finding a reuse for a material that is often a byproduct of animal breeding," notes Shahin Rahimifard, an industrial engineer and professor at the U.K.'s Loughborough University. "This assumption has swayed [views of] the overall environmental performance of leather because you are basically saying 'if I didn't use it, it goes into landfill.'"

Others argue that the meat and leather industries are inherently linked at the hip, that leather should be seen as a "co-product" of the meat industry — sharing in the mutual responsibility for environmental harm.

ignores its links to environmental harm all along the fashion supply chain. This includes potential deforestation (<https://edepot.wur.nl/566179>) in cattle-ranching hotspots such as the Amazon (<https://www.sciencedirect.com/science/article/abs/pii/S0016718520300737>), methane release during cattle rearing, heavy resource use and high levels of waste, serious pollution of water and air, along with animal welfare concerns. In her view, "every company that uses leather should understand the supply chain, where it comes from, and mitigate the risks." "The leather industry is as toxic to the planet as it is cruel to animals," according to Yvonne Taylor, vice president of corporate projects at PETA (<https://www.peta.org/>), the animal rights NGO. Shaping skins into leather relies on the use of harmful chemicals, toxic mineral salts, and other harmful substances, she adds. "Tannery runoff contains large quantities of pollutants such as lime sludge, sulfides and acids."



Leather animal hides ready for production. Industry advocates and critics fiercely debate whether leather is a "byproduct" or a "co-product" of the meat industry. But many experts acknowledge that current production practices are responsible for a wide range of environmental harm. In producing countries such as Bangladesh, environmental harm derives from the use of harmful industrial chemicals, and the dumping of tannery waste into waterways. Greenhouse gases are also emitted during processing, says Sanjoy Paul, a researcher at the University of Technology Sydney. Image courtesy of PETA/Karremann.

"Leather is not a 'byproduct' or 'leftover' of the meat industry, but a \$100-billion industry in itself; it exists because of demand, not due to [meat industry] waste [reuse] concerns," Taylor says. Others believe the industry as a whole gets a hard rap and emphasize how it is changing. "Like many other industries, leather is an input-intensive industry. It does require a lot of chemicals, water, and energy," says Fernando Bellese, WWF's (<https://www.wwf.org.uk/>) senior director of beef and leather supply chains. "If you're not managing those things well it can lead to water pollution, air pollution, and so on."

supply chains. "If you look at the leading companies nowadays, they are very modern. They have high technology in terms of wastewater treatment, in terms of chemical management," says Bellese.

There are "gradients of maturity" within the industry," agrees Kim Sena, with Leather Naturally, (<https://www.leathernaturally.org/>) an industry group. He points out that leather is far more durable than other fashion materials, slowing down textile consumption and disposal rates, if used wisely.

"But we have to think about other issues," he agrees, such as animal welfare, cattle impacts, and leather-processing pollution.



The vast majority of animal-derived leather is sourced from cattle. Industry representatives and others state that leather made from skins is a recycled "byproduct" of meat and wool production. "Leather is steeped in circularity and indeed is one of the oldest forms of upcycling, yet lately it has been viewed negatively for the environmental impacts and animal welfare issues of cattle production," states a WWF report published in 2022. Image by Daniel Foster via Flickr (CC BY-NC 2.0).

Leather's circular solutions

Implementing circular practices during production (<https://www.mdpi.com/1996-1073/16/1/564>) can reduce leather's environmental burden, according to experts. Recovering, reusing and reducing waste is a first step, says Marika Gargano, a researcher at Italy's University of Naples Federico II, whose work focuses on finding natural and biobased (<https://www.mdpi.com/2079-6412/13/4/775>) solutions within leather production.

A next step is "returning to original tanning methods," using vegetable tanning (<https://link.springer.com/article/10.1007/s11367-023-02232-3>) instead of chrome-based tanning. A recent study (<https://link.springer.com/article/10.1007/s11367-023-02232-3>), notes

reductions" of toxins and released CO₂, while saving water.

When it comes to post-tanning — the processing phase that gives leather its final color and texture — the current predominant chemical use can amount to a "bomb" for the environment, Gargano says, if released via wastewater. "We need to replace all these reactants with natural ones," she says, which means "introducing enzymatic reactions, natural dyes, [and] proteins instead of [using] resins."

However, significant barriers, especially involving cost, are impeding implementation of these sustainable solutions globally. Traditional leather is primarily produced

(<https://www.sciencedirect.com/science/article/abs/pii/S2214785323005436>) in China, Brazil, Russia, India, Italy, South Korea, Argentina, and the U.S., all with varying levels of industrial sophistication, financial access, and environmental regulatory standards.



Leather hides drying in the sun in Kanpur, India. Chrome tanning is the most prevalent method practiced worldwide, but chromium is highly toxic. Untreated wastewater from the tanning process can release a witches' brew of chemicals into the environment including heavy metals such as cadmium, lead and arsenic. Image by Neil Palmer/IWMI Flickr Photos via Flickr (CC BY-NC-ND 2.0).

"The leather industry may [currently] lack the resources and support to establish a [circular economy] model," says Sanjoy Paul, a researcher at Australia's University of Technology Sydney.

Likewise, "The concept of reusing, repairing, refurbishing and recycling leather products [to extend their life cycles] has not been well-established in developing countries."

In Paul's view, a range of industry actions will be required globally to address its large environmental footprint. Alongside needed circular solutions, these include treating wastewater efficiently, minimizing toxic chemical use, and developing "error-proof" management

(<https://www.worldwildlife.org/publications/leather-also-has-a-role-to-play-in-the-fight-against-deforestation>).

"The overall system should be monitored and audited as per local and international environmental regulations," Paul wrote in an email. And that "is not a one-time [task]. The industry should work endlessly to protect the environment."

Leading by example

The Scottish Leather Group

(<https://www.scottishleathergroup.com/circular-manufacturing>) is one company aiming to clean up leather's environmental image through its own example. The firm claims that its products have the lowest carbon footprint of any leather manufactured anywhere, achieved through a suite of circular production solutions developed over recent decades.

The company started with a desire to minimize waste, and to utilize *all* of the leather it sourced in a variety of final products, says Warren Bowden, head of innovation and sustainability at the company. "Historically," he says leather production has used "a linear approach ... with roughly 90% of the hide weight never end[ing] up as leather."

The Scottish Leather Group aims at using everything — not only making leather, but also recovering unused raw material to be sold as biofuels or other products, rather than sending it as waste to a landfill. Anything that's not "recoverable saleable commodities" the firm uses as fuel in its leather factory, displacing fossil fuels, says Bowden. "That's a massive piece in terms of reducing the carbon intensity of the product."

The company has also engineered an innovative waste recovery system, taking back leather seats it has sold to airlines, for example, then shredding and burning them to "create the energy for the next set of [manufactured] leather seats," he explains. Though this energy recovery scheme is still relatively small scale, Bowden says the company ultimately plans to recover used leather to be refashioned into other materials. "All that leather must go somewhere. And for me, there's a massive opportunity to recover it, take it back and do something more interesting with it. That's where ... the future is."

Such solutions have so far enabled the company to slash its landfilled waste by nearly 80%.

(<https://www.scottishleathergroup.com/circular-manufacturing>) The goal, notes Bowden, is to reduce that to zero by 2025. Similarly, water use in manufacturing is down thanks to a treatment system that cycles used water back into production. That has slashed the need for water drawn from a private Scottish loch. "We found that by treating [water] to the point you could recycle it, you could significantly reduce the amount you're actually drawing," he says.



Leather is loaded into tumblers in Kanpur, India. The city is one of India's largest leather producers, and the industry there is associated with a range of environmental impacts, including the release of toxic wastewater. Image by Daniel Bachhuber via Flickr (CC BY-NC-ND 2.0).



Leather production today mostly follows a linear model. But experts say that applying circular solutions could limit waste and reduce environmental impacts. Innovative alternative leather-like materials — made from agricultural waste, for example — are increasingly being marketed, promising to reduce ecological harm and create "ethical" options. Though these alternatives can provide circularity, producing with them can come with their own challenges, often including a continuing dependence on plastics to achieve traditional leather's durability. Image by Claudia Daggett via Flickr (CC BY-NC 2.0).

Leather alternatives and the trouble with plastics

While some long-established leather companies aim to reduce impacts and go circular, other firms and researchers are innovating to produce alternative fashion materials.

Jinali Mody, founder of the startup Banofi (<https://banofileather.com/>), for example, sees a sustainable alternative to leather in the millions of tons of banana waste produced in India each year. Her company purchases banana waste directly from smallholder farmers and fashions it into leather-like materials.

"We source our waste directly from the farmers and we provide them with additional income for their waste," she says. "These farmers typically would dump [the banana waste] or burn it."

Currently, Banofi's products consist of around 60% banana crop waste, 20% other "natural components," and around 20% synthetic additives, including recycled plastics.

"We're extending the life of waste," Mody says, noting that at the laboratory scale, the firm's product has proven to be 100% circular because after its initial use, it can be reworked into harder materials, such as book covers.

According to Mody, her firm's banana leather outperforms both bovine and "vegan" leathers derived entirely from plastics such as PVC. In addition, Banofi requires vastly less water, and achieves roughly a 90% carbon reduction compared to animal and plastic-derived leather, while emitting no toxic waste during production, according to the company.

Banofi is just one innovative example of newly launched companies manufacturing alternative leather products (<https://news.mongabay.com/2022/04/sustainable-fashion-biomaterial-revolution-replacing-fur-and-skins/>) in an expanding market predicted to be worth \$45 billion by 2025 (<https://www.grandviewresearch.com/press-release/global-synthetic-leather-market>). Apples, pineapples, cacti, tea waste, fungi, and lab-grown leather (<https://earth.org/lab-grown-leather/>) products are all in the works. And even as a range of "biobased" products are produced, a strong market for "vegan" or alternative leather already exists.

But many of these new products suffer from a serious drawback: their heavy reliance on plastics to increase durability.



Based in India, Banofi turns banana waste into a leather-like product. "It's ... a journey where we're working to get [our product] to a more biobased material," explains company founder Jinali Mody. A 100% leather biomaterial is technically feasible, but doesn't currently fit market standards, she says. Image courtesy of Banofi.



Persiskin, a Spanish company, uses persimmon waste produced in the Valencia region to create a leather-like material. Thousands of tons of this fruit end up as agricultural waste each year. Stephane Merit, sales director for Persiskin, sees its biobased leather product as an opportunity to create a locally based circular solution that also supports farmers. "It's a new paradigm for this region, where [farmers] not only ... sell what's on the tree, but they now have an alternative source of income for the [fruit] that's wasted." Image courtesy of Persiskin.

that produces a leather alternative sourced from cacti, says that even though its products are not "100% plastic-free," they outperform traditional leather and polyurethane products from a sustainability perspective. Looking across the entire leather life cycle, he states that circular farming solutions reduce water use and cut out harmful chemicals.

Achieving completely plastic-free biobased products is an ambition of alternative manufacturers, but remains a technical challenge yet to be overcome.

"If you have a 100% plant-based alternative to leather, it's not going to last," Velarde explains. As a result, some synthetic additives are necessary to "not only make a material perform, but also make it desirable for designers."

"The vegan market right now for leather is dominated by plastics. That is true for both purely plastic material, but also plastics that have been mixed in with biomass," explains Griffin Christiansen, a regenerative strategist at Natural Fiber Welding (<https://www.nfw.earth/>). His company hopes to displace plastics entirely by basing its source material on ingredients such as rubber and cotton, and by implementing circular solutions throughout production.

"I think the only true alternatives are products that will break down in nature or are not using plastic," Christiansen says.



A range of established companies and startups are innovating to produce leather from alternative sources. Mexico-based company Desserto makes it from the prickly pear cactus. Though the company's products are not plastic-free, Desserto CEO Adrian Lopez Velarde emphasizes that a firm's entire production process must be assessed to accurately evaluate environmental impacts. Image courtesy of Desserto.



U.S.-based company Natural Fiber Welding produces Mirum, a leather alternative that includes natural rubber. "I think the only true [sustainable leather] alternatives are products that will break down in nature or don't use plastic," says Griffin Christiansen, a regenerative strategist with the company. In addition to selecting source materials that will break down in nature, he says that the firm's aim is to implement circular farming practices in its supply chain. Image courtesy of Brett Rhoades for NFW.

The future of leather

Steeped in history, the leather industry is changing fast, say analysts. But its future is advancing in several directions at once, as some manufacturers bet that synthetic materials or plastic-free biobased materials will come to the fore, while others see big opportunities for a cleaner, nonpolluting and toxic-free hide-based leather industry.

In the end, all this diversity may triumph. "I do think we need many materials, we don't only need leather," to achieve sustainability says WWF's Bellese. "What doesn't make sense to me is to discuss not using leather while we are [still] raising cattle."

In his view, innovating with new materials is necessary. At the same time, the traditional leather industry needs to focus on raising cattle responsibly, replacing and reducing chemical use, limiting water utilization, introducing more renewables, and ensuring effective wastewater treatment. "There are solutions [already available] for all those things," he adds.

Some experts are cautious about exclusively backing leather alternatives because in the attempt to avoid traditional leather production environmental pitfalls, makers may exacerbate other problems. "I have a positive opinion about these [alternative leather] developments, as long as they are not fossil-fuel based," says

thinking about end of life is essential if we're aiming for circularity."

Banner image: A woman is laying leather out to dry in Bangladesh.

Image by United Nations/UN Women/Rashid Probal via Flickr
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