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Feminist LCAs: Finding leverage points for wellbeing within planetary boundaries

Katherine Ellsworth-Krebs [a,b,*], Monia Niero [c,d], Tullia Jack [e,f]

[a] Imagination Lancaster, Lancaster Institute for the Contemporary Arts, Lancaster University, United Kingdom
[b] Department of Design, Manufacturing and Engineering Management, University of Strathclyde, James Weir Building, Office JW701a, 75 Montrose Street, Glasgow G1 1XJ, United Kingdom
[c] Aalborg University, Department of Planning, Research Group "Design for Sustainability", A.C. Meyers Vænge 15, 2450 Copenhagen, Denmark
[d] Sant'Anna School of Advanced Studies, Sustainability and Climate Interdisciplinary Center, Piazza Martiri della Libertà 33, 56127 Pisa, Italy
[e] Department of the Built Environment, Aalborg University, 7k Fredrik Bajers Vej, Aalborg Øst, North Denmark, 9220 Copenhagen, Denmark
[f] Department of Service Studies, Lund University, Universitetsplatsen 2, Helsingborg, Sweden

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ABSTRACT

Life Cycle Assessment (LCA) studies are valuable tools for identifying high impact processes and redesigning supply chains. However, LCAs have limits, in the sense that they offer insight into relative sustainability and don't question whether a product, or its use, is sustainable in absolute terms. In this intentionally provocative paper, you join Emma, a fictional average American 15-year-old, as she consults an LCA researcher, a sustainable consumption expert and a sociologist to investigate the best way to reduce the environmental impact of her hair removal. This paper presents a streamlined LCA for shaving, waxing and laser and connects this to a socio-material analysis of the history of hair removal in the USA to offer intervention into leverage points beyond Emma's choice of product. Our argument is not that avoiding shaving or waxing or laser is 'the best' action an individual could take to lower their environmental impact, instead we highlight how even the smallest activities coalesce into billion-dollar industries globally, with attendant billion tonne emissions. Thus, we utilise some of Danielle Meadows' twelve strategic leverage points to change systems in order to identify other interventions, such as (6) shifting information flows to make LCAs more impactful and accessible; (4) self-organising to normalise hairiness; or (3) changing the goals of the system. For example, valuing wellbeing over profit would arguably lead to regulation preventing medical professionals from marketing painful non-medical procedures. This paper reflects on how individuals make sense of their environmental impact within systems and argues for an increased emphasis on global wellbeing and absolute sustainability.

1. Introduction

As sustainability researchers we are asked, "what is better for my environmental footprint?" Especially for mundane things like is it "better to dry hands with paper towels or an air dryer"? The answer is very often "it depends", as the impact of an apple grown on one farm or a smartphone manufactured in one factory are not the same as all other apples and smartphones; and, also it depends on which, and how, metrics are compared and weighted. Do we focus on climate change, land use, water use or other environmental impacts?

Life Cycle Assessment (LCA) studies help us answer these questions. LCA is "a well-established methodology with a consistent and coherent framework of mutually exclusive and collectively exhaustive impact categories to quantify and compare the contributions to all these impacts in a quantitative manner" (Hauschild, 2015: 2; Hauschild et al., 2018). LCAs can compare the impact of oat milk to cow milk and give an answer in terms of *relative* environmental sustainability. For example, in LCA studies with different contexts and impact metrics, oat milk is consistently more environmentally sustainable (Geburt et al., 2022; Riofrio and Baykara, 2022; Röös et al., 2016). LCAs enable comparison between areas of consumption as well. For example, LCAs show that it makes a *relatively* bigger difference to improve insulation rather than turning off lights because heating is a much larger household energy demand than lighting (e.g., in the UK the former is about 66 % and lighting is only 4 % (Palmer and Cooper, 2013)). In this way, LCAs are valuable for identifying high impact processes and redesigning supply chains. However,

* Corresponding author.
E-mail addresses: Katherine.Ellsworth-Krebs@strath.ac.uk (K. Ellsworth-Krebs), monia.niero@santannapisa.it (M. Niero), tullia.jack@ses.lu.se (T. Jack).

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LCAs have limits, in the sense that: "Product A may be more environmentally sustainable than product B, while neither is sustainable in *absolute* terms" (Hauschild, 2015: 4, emphasis added). This is why LCA researchers have begun to investigate methods for Absolute Environmental Sustainability Assessment (AESA) based on LCA, because a comparison of two products does not inform us whether these are "meeting sustainability goals at a societal level" (Ryberg et al., 2018: 1414). Indeed, as Ryberg et al. (2020: 766) explain, "given that population and consumption are increasing at a faster rate than technological improvements, there is a need for introducing assessments that can indicate if current technologies are actually good enough and not just better than the alternatives."

LCA-based AESA is an important step in sustainable consumption research because it is not enough to compare environmental impact of different modes without assessing these within a list of environmental carrying capacities[1] (see Bjørn et al., 2020 for an excellent review of this emerging field). Bjørn et al. (2020) explain the difference with a transport example. When doing a *relative* environmental sustainability assessment between a diesel car and electric train for someone's annual commute, the electric train may turn out to be the best in multiple performance categories. However, this does not acknowledge other options, for instance, that commuting by bicycle would have the lowest impact. Indeed, if the analysis were extended into an *absolute* environmental sustainability assessment comparing options to the 1.5 degree climate goal of the Paris Agreement, "it may then turn out that the bicycle is the *only* mode of transport whose climate impact does not exceed its assigned carrying capacity" (Bjørn et al., 2020: 2, emphasis added). Admittedly, adding in metrics for carrying capacity (e.g., planetary boundaries or share of safe operating space) and (ideally) a measure of equality or 'sharing principle' (e.g., Grandfathering,[2] Equal per capita) (Bjørn et al., 2020) is a complex task. Yet it is possible to acknowledge the limits while starting to create a consistent and coherent framework to quantify and compare options (c.f., Ryberg et al.'s, 2020 study of a Danish utility company). Thus, AESAs challenge us to go beyond *relative* sustainability and observe when "priority should be given to reduce impacts related to climate change" (Ryberg et al., 2020: 775).

In this paper, we – an interdisciplinary team combining an LCA researcher, a sustainable consumption scholar, and a sociologist – offer some possibilities for how to respond when an *absolute* assessment suggest more ambitious interventions are required. In so doing, we bring together two emerging and resonant concepts: *absolute environmental sustainability* in LCA scholarship and *sufficiency policies* in sustainable consumption literature. We explore this through the lens of Emma, a fictional 15-year-old average American girl based on Nilson's (2021) collation of census and other population datasets. Emma wants to live within planetary boundaries (Rockström et al., 2009) and is wondering about the impact of her hair removal. Section 2 explains our methodology involving first a streamlined LCA of three different methods of hair removal, before using LCAs creatively to explore more ambitious reduction options. Section 3 presents the results, explaining the streamlined LCA, its limitations, and revealing that the use phase mattered more than the embodied impact from production of the product in this context. Inclusion of the use phase leads to shaving having the highest impact for global warming potential, yet Emma wants to go beyond her individual choice of the product she chooses and how she uses it. Thus, Section 4 turns to a socio-material analysis and explores the history behind hair removal in the USA. In so doing, we employ Meadows' (1999) leverage points to identify missed interventions and future opportunities for rewriting cultural conventions. Finally, we conclude our discussion in Section 5 by reflecting on how the climate emergency challenges us in many contexts to not ask what product is the most environmentally-friendly, but rather how we can stop resource intensive practices that don't improve wellbeing.

2. Method: a streamlined LCA of shaving, waxing and laser hair removal

Emma has just turned fifteen and is becoming a self-aware young woman. Like her friends around her, she starts to remove her leg hair and wants to find out the best way to do it in an environmentally sustainable way. She begins searching online and in academic journals and finds that relatively little is known about quantitative comparisons between popular hair removal strategies.

To our knowledge there are no LCA studies comparing different hair removal methods. Most LCA studies in the area of personal care focus on comparing alternative products fulfilling the same function. For example, Lyne et al. (2020) compared the potential environmental impacts of a traditional plastic and electric toothbrush, as well as a plastic manual toothbrush with replaceable heads and a bamboo manual toothbrush. In the personal hygiene segment several studies have been conducted comparing the environmental performances of alternative menstrual product options, (e.g., Fourcassier et al. (2022), Hait and Powers (2019)), showing that consumer habits play a key role in the identification of the best alternative. The environmental footprints of shampoos and other rinse-off cosmetic products (Golsteijn et al., 2018), household detergents (Golsteijn et al., 2015) and hand drying systems (Gregory et al., 2013; Joseph et al., 2015) have also been explored. The main point of discussion when assessing the potential environmental impacts in the personal and professional health care sector is often on the packaging and how to improve packaging design (Yokokawa et al., 2020; Kim and Park, 2020; Agarwal and Thiel, 2013). The focus on packaging is common in many LCAs and historically the first LCAs were performed on packaging (Hunt and William, 1996), yet packaging has by no means the biggest impact. Thus, while some progress has been made in the LCA literature on personal hygiene, hair removal has so far escaped investigation.

Emma is considering different ways of removing hair from her body, and most of her friends either shave, wax or laser at home. For the moment, Emma's looking for a *relative* comparison between these methods for removing her leg hair and goes to an LCA expert for help.

Emma's LCA expert recommends doing a streamlined LCA (also known as simplified LCA or screening LCA) because it is an efficient way to evaluate the environmental attributes of a product, process, or service life cycle. It aims at simplifying LCA to provide essentially the same type of results as a detailed LCA (i.e., covering the whole life cycle), but using qualitative and/or quantitative generic data. A streamlined LCA is not meant to be a rigorous quantitative determination, but rather a tool for identifying environmental "hot spots" and highlighting key opportunities for effecting environmental improvement (McAloone and Pigosso, 2018).

The goal of the streamlined LCA performed for Emma is to compare alternative methods for full leg hair removal, namely a) shaving, b) waxing and c) laser. With an LCA it is possible to compare different ways of providing a function, and this means that a functional unit (i.e., "the quantified performance of a product system for use as a reference unit" (ISO, 2006)) must be defined. To satisfy Emma's aims, the functional

[1] We base our definition of carrying capacity based on Bjørn et al. (2020). First, carrying capacity is synonymous with for example planetary boundaries or planetary limits or safe operating space. Essentially, carrying capacity refers to the maximum persistent impact that the environment can sustain without suffering perceived unacceptable impairment of the functional integrity of its natural systems or, in the case of non-renewable resource use, that corresponds to the rate at which renewable substitutes can be developed.

[2] Grandfathering is an allocation principle in absolute environmental sustainability assessments and can take many forms. The basic principle is to 'grandfather' in past emissions to future emissions allowances. This could lead to a (relatively) equitable sharing of contributions, for example, by grandfathering in past emissions developed countries may be expected to reduce peak emissions by at least 80 % by 2050 while developing countries maintain a trajectory until 2020 with cuts of 20 % against 1990 levels by 2050 (see extensive exploration by Bjørn et al. (2021)).

unit was defined as "hair removal on legs for a 15-year-old girl with German ancestry for 10 years done at home in Washington DC". To build the LCA model we chose products from Amazon available for delivery to Washington DC, where Emma lives, in 2022 and kept them constant for the following ten years (Table 1). Based on the producers' recommendations and Emma's German ancestry, we estimate that she will shave on average 104 times per year (3 times per week during summer, twice per week in spring and autumn and once per week in winter), wax 6 times per year (once per month only during spring and summer) and laser 8 times in the first year, 4 in the second year and then touch up once a year for the next 8 years with each session constant at 45 min, for a total of 20 treatments in 10 years. In order to be able to compare the three product systems it is necessary to identify how much of each product is needed to fulfil the functional unit, this is the so-called "reference flow". The reference flows considered for the three system are: a-shaving) 10 packets with 18 razors each, equal to 180 razors; b-waxing) 60 packs including 24 strips and 4 post wax calming oil wipes, each, equal to 1440 waxing strips and 240 post wax calming wipes, c-laser) 2 products including each 1 laser, 2 razors and 1 pair of glasses.

In order to solve Emma's dilemma (i.e., whether to shave, to wax or to laser), we first performed a comparative streamlined LCA of the three different hair removal methods, considering only the raw material production and transport, as represented in Fig. 1. Each of the product systems under study includes the production of the raw materials (and potential auxiliary materials) used for the manufacturing of the main product, the production of the packaging (i.e., the primary packaging which is in direct contact with the product), as well as the transport of the raw materials and packaging to the manufacturing stage. The main inputs considered in the Life Cycle Inventory (LCI) modelling of each of the alternatives considered are presented in Fig. 1 and refer to the inputs of materials and transport of the main product and packaging. The streamlined LCI was built using secondary generic input data and it should be noted that it is based on assumptions made by the authors both on the type and amount of materials used, as well as for the transport phase, so this might not be representative of the products listed in Table 1. We used SimaPro v.9.3.0.3 (PRé, 2013) and the ecoinvent 3.8 database allocation, cut-off by classification to build the LCI (Weidema et al., 2013). Details on the SimaPro model and assumptions made are provided in the Supplementary information (SI).

Table 1
Top seller at-home hair removers for shaving, waxing and laser (13/07/2022), including assumptions on the number of treatments in 10 years and the number of products needed.

Removal	Product	Treatments in 10 years	Number of products in 10 years (=reference flow)
Shaving	Gillette Venus Daisy Classic Disposable Razors for Women https://www.amazon.com/Gillette-Daisy-Womens-Disposable-Count/dp/B005FUFPGO?th=1	1040 with the assumption of 104 treatments per year, i.e. 3 times per week during summer, twice per week in spring and autumn and once per week in winter	180 razors. One packet contains 18 razors and we assumed an average of 5,78 shaves per razors, thus requiring the use of 1 packet (=18 razors) per year to fulfil 104 treatments
Waxing	Nad's Body Wax Strips https://www.amazon.com/Nads-Body-Wax-Strips-24/dp/B000NQ4JGM	60 with the assumption of 6 treatments per year, i.e. once per month only during spring and summer	60 packs with 1440 strips. One packet contains 24 strips and we assumed that this is enough for 1 treatment, therefore 6 packs (with 144 strips) are needed in 1 year and 60 packs with 1440 strips in 10 years
Laser	XSOUL At-Home IPL Hair Removal https://www.amazon.com/At-Home-Removal-Permanent-removal-Painless/dp/B0828JD1WF	20 with the assumption of 8 times in the first year, 4 in the second year and then touch up once a year for the next 8 years	2 products. According to the producer the product comes with 36-month warranty, therefore we assumed that 2 products are needed to perform the 20 treatments

In a further LCA analysis we included also the use stage in the LCI modelling, as represented in Fig. 1, therefore considering the input of resources in such life cycle stage (i.e., water and electricity needed to warm the water in the case of shaving and waxing, as well as the electricity used for laser). We made some assumptions in relation to the amount of water needed during showering, as well as the electricity needed to warm up water (details are presented in the SI).

The life cycle stages considered are raw material acquisition and use. The raw material acquisition includes the production and transport of the main product (razor, wax and laser, respectively), the auxiliary materials (wipes for wax, and razer and glasses for laser) and the packaging. In Fig. 1, the use stage (in italics) includes the use of resources (i.e., water and electricity) consumed by Emma. In the initial LCI modelling only the raw material acquisition stage was considered, meanwhile in the second LCI modelling also the use stage has been included.

The Life Cycle Impact Assessment (LCIA) method used to quantify the potential environmental impacts of the three different hair removal options is ReCiPe 2016 Midpoint (H) V1.06 (Huijbregts et al., 2017). We focused on three impact categories, namely Global Warming, Land Use and Water consumption, since Climate Change, Water Use and Land Use are the three metrics most commonly looked at according to the review on 45 LCA-based AESA by Bjørn et al. (2020).

In reality Emma will also remove hair from other parts of her body, reuse razors and wax more or less intensively as well as mix shaving (both in the shower and out of it) with waxing and laser or other hair removal methods (e.g., plucking), and vary her frequency over 10 years. Of course, Emma's hair removal, and the resulting environmental impact, is likely to be influenced by her various life stages, friendship circle, relationship status, fashion and personal economy. However, despite the many assumptions included in the streamlined LCA, it can be seen as a starting point for deciding about the best option for living within planetary boundaries.

3. Results: what's the most environmentally sustainable hair removal method?

The Life Cycle Impact Assessment results of the first comparative streamlined LCA comparing shaving, waxing and laser with a focus on the products is represented in Fig. 2. It shows the potential environmental impacts on the three impact categories considered (i.e., global warming, land use and water use) in relative terms (i.e., the option with highest impact is given a value of 100 % and the impacts of the other options are represented in relative terms). It can be seen that the alternative with the highest potential environmental impacts for all the considered impact categories is waxing, meanwhile laser is the one with the lowest impacts on global warming and water consumption and shaving has the lowest impact on land use.

The results of the second comparative LCA including the impacts of the use stage are reported in Fig. 3. It provides a different picture compared to Fig. 2, as the hair removal method with highest impact in all impact categories is shaving, due to the impacts of the use phase, i.e. the electricity used to warm the water and the water used in the shower. The option with lowest impact is waxing for global warming and water consumption and laser for land use. This is a completely different scenario than the one represented in Fig. 2, when only the raw material acquisition stage is considered.

Emma is a bit confused and overwhelmed by these results. The

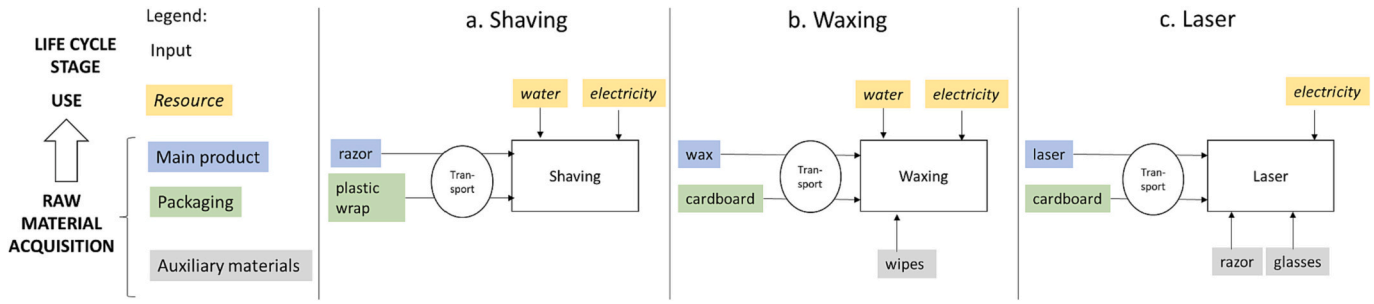

Fig. 1. Simplified Life Cycle Inventory modelling considered comparing the three alternatives for leg hair removal: a) shaving, b) waxing and c) laser.

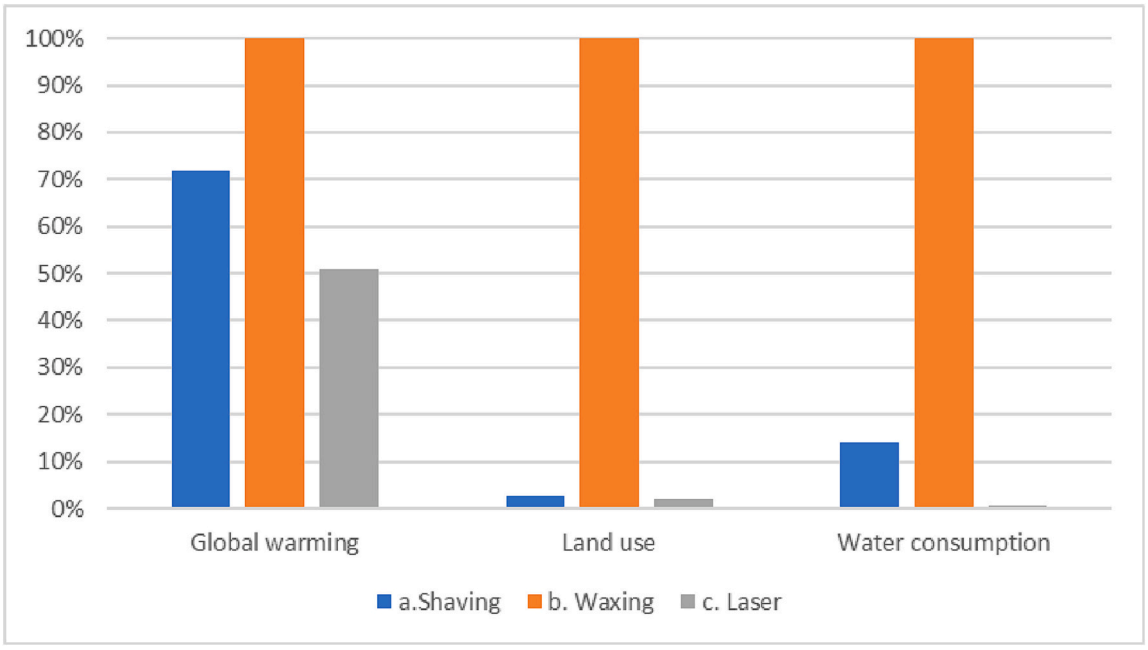

Fig. 2. Comparative Life Cycle Impact Assessment (LCIA) results with focus on the product in the case of a) shaving, b) waxing and c) laser.

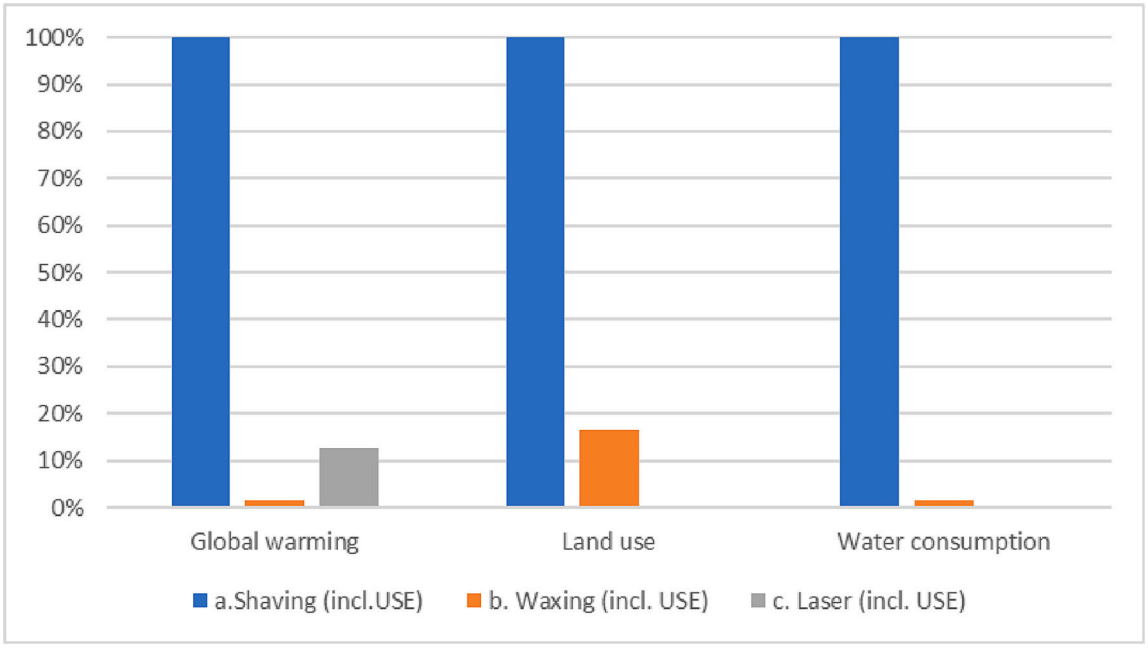

Fig. 3. Comparative Life Cycle Impact Assessment (LCIA) results with product and use stage combined in the case of a) shaving, b) waxing and c) laser.

analysis of the three products only (Fig. 2) suggests that waxing has the lowest environmental impact overall. But how does she prioritise between global warming, land use and water use? If her top priority was land use: then shaving would be the best option. For the moment, Emma wants to make sense of the scale of difference between these product's environmental impacts and she gets out a popular science book on Life Cycle Assessments, *How Bad Are Bananas* by Mike Berners-Lee (Table 2). Considering the title of the book, Emma plays with a banana comparison (0.11 kg CO_2 eq). Over the ten-year period of hair removal is like eating 120 bananas (waxing, biggest impact) or 61 bananas (laser, lowest carbon option). *That's nearly twice as big of an impact,* she thinks. Then she puts these products in comparison to a pair of jeans (19 kg CO_2 eq) and realises it's quibbling between 0.4 (laser) or 0.7 (waxing) of a pair of trousers. Emma wonders, *Why she would even spend time worrying about ten years of hair removal when it's not even the same impact as an entire pair of jeans!*

Then Emma starts comparing these everyday products with the inclusion of the use phase. Now she's looking at a high of about 17,364 bananas (shaving) to a low of 263 bananas (waxing). That feels like a more substantial scale of difference. Yet, this number of bananas is hard to imagine: it would take Emma about 48 years to eat that many bananas if she ate one a day. So she looks for a more comprehensible comparison and calculates that over the 10-year period, shaving is like purchasing four laptops, while waxing and laser are equivalent to only about half a laptop. She's shocked! Her mundane, little practice of shaving could add up to the same amount of embedded carbon as four laptops! *That's not insignificant.* When Emma reflects that over a ten-year period she might purchase two or three laptops (e.g., recommendations suggest a good laptop lasts three to five years), she is surprised to consider her shaving adds up to more. Although then she concedes this is comparing the product and use phase of shaving to only the product (i.e., laptop) and not the energy used to power it or the data centres and she wants to give up because it's so difficult to make sense of the LCA results.

That said, Emma does have one big takeaway from the streamlined LCAs, these comparisons helped her to see the way she uses these products makes a difference. While she cannot easily influence the supply chains and embedded resources in the products themselves (Fig. 2), she *can* change the way she uses them (Fig. 3). Emma likes to shave in the shower, but the electricity for heating this water and the rapid flow rate is what moves the impact of this practice from being similar to the environmental impact of half a pair of jeans up to 101 pairs over a ten-year period! Maybe she'll try shaving from a cup or basin in the future.

Emma's surprised by how this little activity can add up and grateful that the way she conducts her hair removal, the use phase, rather than the product, is considerable so she does have some agency. But she's still unclear about what to do with her LCA, considering the different impact measures, and the specificity and assumptions for her own local context and way of removing hair.

3.1. Assumptions, generalisability and what next?

Unfortunately, Emma did not get a clear answer to her dilemma, but she recognises that even to do a streamlined LCA, there were a number of assumptions, each one more specific than the last, making the calculations non-generalisable. For instance, she did not even think about the money which may ultimately constrain her ability to choose. She also chose her specific geographic location dictating the infrastructures and impacts of energy and water consumption. She included the energy for heating water in a shower to shave, even though some people might not shave in the shower, and others would use shaving cream or foam. She also assumed an average water flow, although a water-efficient showerhead uses approximately 9 l per minute, while an older style showerhead uses up to 20 l per minute (GMW, 2018). The waxing product she chose does not need to be heated up, thus avoiding energy consumption and related environmental impacts. Yet many waxing products do in fact require heating in the microwave or boiling water, thus increasing energy consumption. Emma also figured she'd be too lazy to wax in the winter and only included six treatments (i.e., once a month in the warmer half of the year), yet she thought she might shave once a month in the winter for special occasions (e.g., a fancy holiday dinner where she'd wear a short dress) because it's lower effort. When it came to purchasing an at-home laser hair removal device, Emma figured she could get by with two products, even though the warrantee lasts for only three years because after the first two years only 'touch ups' are meant to be required. As a fifteen-year-old with a limited budget, Emma hopes these devices last longer than their warrantees, but an adult may have purchased three or four for the ten-year period which would give different results. Furthermore, both waxing and lasering are often performed at salons, fundamentally changing the impacts with shared infrastructure, but also increased impacts required for heating, cooling and maintenance of the business and its premises. Hair removal out of the home also requires travel to and from salons, and the impact of this will vary on distance and method of transport (e.g., walking, cycling, driving, public transportation) which also changes the consumption profile. We did not include transport from the manufacturing factory to the residence, since we did not have enough information, but distance travelled and packaging used in travel will also impact final numbers, as recycling options and disposal. Was shaving really the worst? Her slim purse certainly hoped not!

The list of assumptions highlights how results depend on what's included in the assessment, and the results of the streamlined comparative LCA shows that the best hair removal method changes depending on the impact category chosen and the life cycle stages considered, highlighting that the use stage has a relatively bigger contribution to the potential environmental impacts, compared to the raw material acquisition stage. Emma is even more confused at this point as she sees how geography, ethnicity, and preferences all impact the assessment results and wonders why she even wants to shave in the first place. Emma comes across a blog on AESAs and starts to understand, it's not choosing the lesser of two evils, but considering her entire lifestyle. She turns to the social sciences, for more inspiration on living within planetary boundaries.

Table 2
Translating Global Warming impact of shaving, waxing and laser use over 10 years to everyday products (kg CO_2 eq from Berners-Lee, 2020: 39, 104, 129).

Global warming [kg CO_2 eq]	Bananas (0.11)	Cotton jeans (19)	15-Inch laptop (475)
Shaving (9.5)	86	0.5	0.02
w. use stage (1910)	17,364	101	4
Waxing (13.2)	120	0.7	0.03
w. use stage (28.9)	263	2	0.60
Laser (6.7)	61	0.4	0.01
w. use stage (239)	2173	13	0.50

4. Discussion: intervening in paradigms

Emma starts by reading about the systemic factors (e.g., social-material nexuses) that have led her to *want* to remove her body hair. Why does it feel like a *need* for her on a daily or weekly basis when she knows her grandmother, Mary, didn't feel this way and her mother,

Jessica, only shaves for 'special occasions.' Whatever the origin,[3] Emma is fascinated to find that habits of hair removal, beyond faces, in the majority of the USA population is less than a century old. Yet, if she doesn't remove her leg hair Emma is worried her friends will think that she's a hairy feminist. If Emma wants to intervene in these norms, she knows systemic change is required – the responsibility is not only on her shoulders. So she turns to more experts, approaching two social scientists who have written on social trends, sustainable lifestyles, interventions and changing collective conventions in the field of sustainable consumption.

Emma's sustainability social scientists recommend she read research on transformational adaptation, socio-material analysis and leverage points. Since Emma's starting point was living sustainably she begins with the International Panel on Climate Change (IPCC) reports. "Transformational adaptation, which changes the fundamental attributes of a socio-economic system in anticipation of climate change" is now central to the IPCC's call to action as the "human influence on the Earth's climate has become unequivocal, increasingly apparent, and widespread" (IPCC, 2022a). As a result, Emma reads, there is a shift in urgency and an acceptance of radical changes and sufficiency policies required to prevent dangerous and severe climate risks (IPCC, 2022). "Sufficiency policies are a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human wellbeing for all within planetary boundaries" (IPCC, 2022: SPM41). Emma feels alarmed and anxious and sees the urgency of addressing the way society functions, but is still in the dark about how her own life fits into the big picture.

The her social scientists direct Emma to literature on the ratcheting standards of similar practices related to cleanliness, in the contexts of showering and laundering (Shove, 2003; Jack, 2013, 2017, 2022a,b; Kuijer, 2014). But like the lack of LCAs for hair removal, they find little analysis of the complex history of hair removal in sustainability scholarship. Like any practice, hair removal is geo-historically situated, and a brief overview of socio-material developments of hair removal is relevant to understand why Emma feels compelled to remove her hair, and what options she has for shifting this practice. The social scientists recommend Emma explore intervention ideas by reflecting on how these relate to the most strategic leverage points in a system (Meadows, 1999). They point Emma to Meadows et al. (1972), the lead author of *Limits to Growth* who began debates about Earth's carrying capacity and founded the Sustainability Institute (1996) which combined research on global systems and sustainable living. Meadows (1999) sets out twelve places to intervene in a system in increasing order of effectiveness: from taxes and physical infrastructure at the weaker end to the goals of the system and targeting the paradigm out of which the system arises being the most effective interventions.

4.1. Missed interventions enabling ratcheting standards

Emma now recognises that her desire to remove hair from increasing areas of her body, from her face to legs to armpits to pubic area, stems not entirely from her own attitudes and choice but from a system of global synchronisation. The social scientists explain how some of the weaker leverage points from Meadows' (1999) twelve strategic targets (e.g., Section 4.1.1 infrastructure, Section 4.1.2 negative and Section 4.1.3 positive feedback loops) were locked-in by the past trajectory of disposable razor systems and a growing hair removal industry.

4.1.1. Material stocks and flows

Meadows' Leverage point ten "the structure of material stocks and flows" argues that "physical structure is crucial in a system, but rarely a leverage point, because changing it is rarely simple. The leverage point is proper design in the first place" (1999: 8). A key design feature that increases the environmental impact of shaving, for example, is the assumed disposability of this product. Rebecca Herzig, author of *A History of Hair Removal*, suggests that disposability was not a key feature when Gillette's safety razor was invented in 1904. At that time, Gillette promised a safer way to remove hair because most shaving up until then was accomplished with a sharpened edge of metal known as a "cut throat" razor, and "bloodbaths could only be prevented by experienced hands" (Herzig, 2015: 37). Due to this danger, shaving was originally considered a masculine activity and even men would rely on a skilled barber if they could afford it.

Gillette's safety razors did not immediately spread to female customers, first they were marketed to men and donated to the US Armed Forces during WWI (facial hair made gas masks less effective and was a safety issue). It was not until WWII, however, when the US War Production Board stopped production of stockings to divert nylon to military purposes that women began to shave their legs regularly since not having nylon stockings revealed leg hair. During the postwar boom in the plastic industry, *Gillette* changed their design and marketed their razors as disposable. Following this, by 1964, surveys indicated that "98 percent of all American women aged fifteen to forty-four were routinely shaving their legs" (Herzig, 2015: 127). It took approximately 60 years for this shift in design to emphasise convenience, ease and disposability creating the conditions for our current expectations, and related infrastructures for regular comprehensive hair removal.

4.1.2. Negative feedback loops

Leverage point eight is "the strength of negative feedback loops" which Meadows (1999: 10) explains as people:

> "trying to weaken the feedback power of market signals by twisting information to their favor. The real leverage here is to keep them from doing it. Hence the necessity of anti-trust laws, truth-in advertising laws, attempts to internalize costs (such as pollution taxes), the removal of perverse subsidies, and other ways to level market playing fields."

Here, again the past trajectory of inadequate market regulation has created lock-in to a system of normalised hair removal, which now makes it harder to apply interventions using the negative feedback leverage point. The hair removal industry has never been well-regulated. In the early days, mixtures of arsenic trisulphide, quicklime and starch were used as chemical depilatories for hair removal (Fernandez et al., 2013). These were homemade concoctions for the most part until the 1850s when industrialists began experimenting with pastes in the expanding slaughter houses on the east coast of the US. Hair on women's faces had connotations of lunacy and deformity, yet the unregulated market of hair removal products led to real dangers. For example, Herzig (2015: 48) quotes a Boston weekly from 1804 that recounts a woman who rubbed a product around her mouth, removing the

[3] Emma reads how histories of hair removal, and its impact on society, generally emphasise "evolutionary" or "gendered social control" explanations (Herzig, 2015). The first argument, based largely on late nineteenth-century medical and scientific scholarship, suggests that the process of natural selection was initiated by hairless hominids' who had greater resistance to disease (e.g., relatively free of flees, ticks and lice) and was reinforced by sexual selection through an unconscious awareness of health and fitness conveyed through hairless skin. Today following this argument, we continue this evolutionary pattern by waxing, shaving and lasering to enhance our attractiveness. The second argument, owing most of its popularity to twentieth-century feminist social scientists, argues that the normalising of hairlessness for women was to produce feelings of inadequacy and vulnerability (Grosz, 1994). Practices of hair removal give women the sense that their bodies are problematic and the work of beautification acts as a 'third shift' alongside paid work (first shift) and unpaid household and caring labour (second shift) (Wolf, 1991). Yet "women asked to explain their own hair removal habits instead point to increased sexual pleasure, attractiveness, and other goals of 'self enhancement.' […] Put simply, Americans tend to describe *other* people as dupes of social pressure, while narrating their (our) own actions as self-directed and free" (Herzig, 2015: 16–17, emphasis in original).

hairs yet '"taking all the flesh with them". American lawmakers did not pass federal regulations to govern the manufacture or sale of hair removers until 1912, and this did not include testing of the enclosed products, it only prohibited certain kinds of labels. Arguably, regulations have not improved in the past century, with the 1970s offering another blow to "truth-in advertising laws." In 1975, *Goldfarb v Virginia State Bar* helped overturn restrictions on physicians' ability to market direct-to-consumers. At this time, there was a glut of physicians in the US due to government schemes aimed at meeting the needs of an ageing population, and in an attempt to reduce health care costs this deregulation occurred (Herzig, 2015). In turn, the marketing of laser hair removal as a more sophisticated 'medical' solution helped pave the way for the rise of Medi-Spas, and medical professionals blurring the boundaries between elective and medical procedures. At the start of the 2000s, laser equipment could cost between $69,000 and $129,000, and conservatively offered a return on investment within a year, with payments direct from customers not being delayed by onerous insurance companies or bureaucratic health care plans. Since there were only weak or no negative feedback loops in place to tackle the medicalisation of hair removal, it was able to establish itself as a necessary and respected part of everyday life.

4.1.3. Positive feedback loops

Leverage point seven is "positive feedback loops" which are self-reinforcing and as a result Meadows suggests (1999: 11) "The more it works, the more it gains power to work some more." We suggest that the rise of pubic hair removal is explained by this positive feedback spiral. In 1971, a survey of US college students reported three-quarters of women described "pubic hair as a powerful weapon in their sexual armory" (Herzig, 2015, p136). But by 2000, American doctors reported that it was uncommon to treat any women under the age of thirty who still had her pubic hair (Herzig, 2015). This is largely attributed to media representations and changes in (online) pornography which affect the meaning of sexual attractiveness and are strongly linked to hairless genitals (Herzig, 2015; Li and Braun, 2017; Smolak and Murnen, 2011). As dresses and skirts became shorter and bathing suits revealed more skin, armpit and leg hair were looked upon as ugly, dirty, unnecessary and unsexy (Smelik, 2015). In this way, the positive feedback loops in place reinforced further entrenching standards of hair removal.

The changing elements show some of the key developments leading to the progressive entrenching of hair removal as a normal and expected part of everyday life (Fig. 4). The social scientists caution that literature on women's body hair is limited because it usually refers to white women, mostly overlooking differences of class and 'race' or ethnicity, typical in sustainable consumption research (Anantharaman, 2018). Yet with her German ancestry and middle-class background the data presented in Fig. 4 is more relevant to Emma and her female ancestors than it would be to other social groups. For example, her great-grandmother Dorothy would likely have put on stockings and not considered shaving her legs when she was a teen. And when Emma's grandmother Mary was Emma's age, Mary would not have worried about removing her pubic hair since three-quarters of American's described pubic hair as sexually attractive. But understanding how (white, middle class) hair removal has conscripted Emma into its ratcheting standards does not answer her question about how to escape. The next section turns to answering this question.

4.2. High leverage points: sufficiency and rewriting cultural conventions

Emma appreciates the systemic pressure on her as an individual to feel the need to remove her hair with the associated environmental impacts. So she asks how these leverage points could be targeted to create more systemic change, reducing pressure to remove hair for her and her friends. The social scientists are excited she's asking, and offer solutions Emma had never imagined by employing Meadows' higher leverage points (e.g., Section 4.2.1 information flows, Section 4.2.2 self-organising, and Section 4.2.3 shifting the goals or paradigm out of which a system arises). Interestingly, the social scientists also find that these three leverage points map onto the three elements (material, competencies and meanings) of a popular framework within the field of sustainable consumption: social practice theory. There are many practice theories, but they reference Elizabeth Shove and colleagues' social practice theory (Watson et al., 2012) which has been central to critiquing the responsibility for change being placed on individuals in environmental discourses and instead attending to the evolution of cultural conventions and structures that shape and constrain individuals' choices (Shove, 2003).

4.2.1. Materiality: information flows

Leverage point six is the structure of information flows because

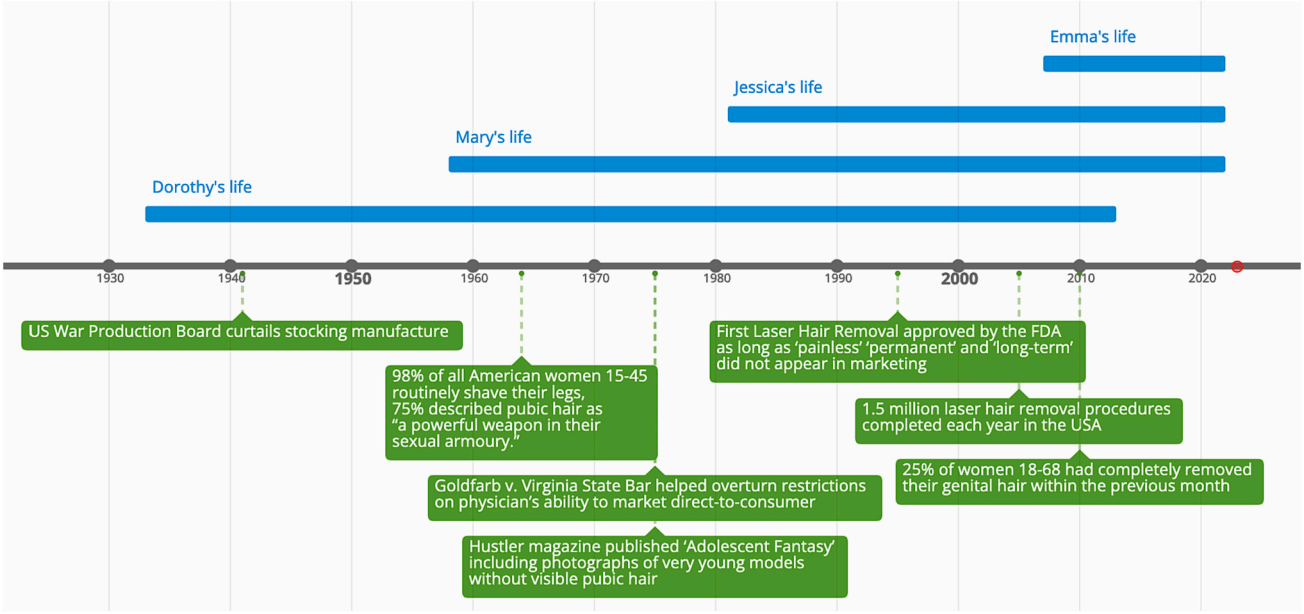

Fig. 4. Developments in hair removal across four generations (1900–2020).

according to Meadows (1999: 13): "adding or restoring information can be a powerful intervention, usually much easier and cheaper than rebuilding physical infrastructure." Arguably, LCAs and AESAs target this leverage point, in an attempt to provide missing feedback on the environmental impacts of products and services. One option available to pro-environmental interventions would be to choose the most efficient hair removal method through a LCA. This would then need to be communicated to hair removalists using policy instruments to make it preferred in the market (Leverage point 5, Meadows, 1999). As we found out with our own streamlined LCA analysis, LCAs are so context dependent that answers vary based on numerous factors such as hair growth rate, tendency to reuse products, geographic location, energy source, shower flow and materials used. There are challenges in the labour, time and cost of doing LCAs because they are so specific and here Artificial Intelligence could improve accessibility (e.g., Kaab et al., 2019; Nabavi-Pelesaraei et al., 2018).

Indeed, another challenge of adding the environmental sustainability as information is a customer or business' ability to make sense of these factors. Emma's streamlined LCA showed that the results changed once the use phase was included. This is an important reminder that what's included in the LCA shapes decisions about where to target intervention. If the LCA is only on the product, which Emma has little control over, it misses out on customer's agency on how a product is used - and in fact, not shaving in the shower mattered more for global warming, land use or water consumption than the razor itself. While the screening LCA provided Emma with valuable information to shift her own practices (e.g., showering) alongside shaving, it doesn't inform Emma about whether a regular practice of hair removal fits within planetary boundaries. This is why AESAs and comparing how this practice fits into a 1.5-Degree lifestyle (which is currently measured as 2.5 tonnes/year (Akenji et al., 2021))[4] would be another important way to advance the impact of LCA research. Adding in metrics for carrying capacity (e.g., planetary boundaries) (Lucas et al., 2021) and a measure of equality (e.g., equal per capita) (Bjørn et al., 2020) was outside the remit of this paper and yet it's crucial to seeing the bigger picture. LCAs' ability to address unintended side effects is limited (Niero et al., 2021) (e.g., how to include the impact that more hair removal could increase consumption of creams for rashes or sunscreen for more exposed body parts in the summer) but we suggest that there is potential for LCAs to support measures of decent living standards (IPCC, 2022: 5–19; Millward-Hopkins et al., 2020). While LCAs do help information flows in making environmental impacts associated with various everyday products and practices transparent, they stop short of nudging our societal paradigm towards sufficiency and wellbeing.

4.2.2. *Competencies: self-organising*

Leverage point four is self-organisation which Meadows describes as "the combination of an evolutionary raw material - a highly variable stock of information from which to select possible patterns - and a means for experimentation, for selecting and testing new patterns" (1999: 15). Meadows suggests that social scientists tend to underestimate the power of social movements and insistence on a single culture limits resilience. Emphasising the power of individuals that have differing ways of engaging, and transforming, a practice (Pink, 2005), the social scientists direct Emma to an experiment that intervened in the ratcheting standards of cleanliness. For example, 31 people in Melbourne engaged in wearing the same pair of jeans for three months without washing them and by the end concluded 'nobody was dirty' (Jack, 2013). The participants in this alternative practice did not begin with that mindset: the group, and a wider survey at the time, suggested most people washed their jeans after every two or three wears and thought that not washing was 'repulsive' (Jack, 2013). Part of the problem is "the opaque nature of community expectations leads to hyper-vigilant self-auditing of personal cleanliness" (Jack, 2013: 415). Emma hears how an experiment, like not washing your jeans for three months, conducted with others as a collective act can lead to social legitimacy and radical changes in materials, competencies and cultural elements. Emma thinks, *I would love to take part in a three month experiment with others committed to not removing their leg hair*. Seeing others with hairy legs would create the space to be hairy at other times and places. There is a power in talking about these 'mundane' and 'delicate subjects' and this gives Emma an idea! Could she try a 'Shave-free September' with other women raising funds for women's illnesses (e.g., breast, ovarian, uterine cancers) or charities (e.g., domestic abuse advice, body dysmorphia, eating disorders) like men grow moustaches in November to raise funds for men's health (e.g., suicide prevention, prostate and testicular cancers)?

Like Jack's (2013) study this leverage point targets the use phase (doing laundry) rather than the production of the product (e.g., supply chain of the jeans) and can be part of a transition. In this way, Emma shifts from focusing solely on herself and the product, to instead considering cultural norms and collective re-scripting of practices.

4.2.3. *Meanings: goals of the system*

Leverage point three is changing the goals of the system and Meadows states that this may be oversimplified as 'profit' according to most corporations, but that the goal often is broadly "to grow, to increase market share, to bring the world (customers, suppliers, regulators) more and more under the control of the corporation, so that its operations become ever more shielded from uncertainty" (1999: 16–17). Arguably in the sphere of hair removal, corporations have hijacked the goals of the system through advertising. As explained in Section 4.1.2 on Negative Feedback Loops, the lack of regulation of chemical depilatories led to advertisers filling this gap by offering reviews of products and assuming an advisory role. For the same reason, brands became important because they supported customers to trust they'd found a product that would not 'take all the flesh,' as well as hair, off. Indeed, hair removal advertisers in the mid-19th century pioneered celebrity testimonials (Herzig, 2015: 50). In this context, manufacturers and advertisements helped normalise hair removal. It's difficult to dismiss that there is a clear 'growth' goal in the hair removal industry. Shaving, waxing and lasering are being performed by increasing swathes of the population (Herzig, 2015; Smelik, 2015) to increasing areas of bodies. In the US, laser hair removal is the second most prevalent nonsurgical procedure for men and women (after Botox injections) (ASPS, 2020; Herzig, 2015). In 2021, the waxing market was valued at $9.8 billion (GVR, 2022c), shaving at $4 billion (GVR, 2022b), and laser hair removal at nearly $800 million (GVR, 2022a) globally. Capitalism and the market growth paradigm (Hickel, 2020; Brand and Wissen, 2021) shape the goals of our system.

Rather than ratcheting up consuming practices generation after generation, what can we do to start organising society around sufficiency and wellbeing instead of growth? The concept of sufficiency cannot be separated from judgements on what is 'enough' or from principles of distributional justice (IPCC, 2022), meaning that we can no longer avoid that there are moral dimensions to climate policy. "The challenge then is to address the upper limits of consumption" (IPCC, 2022: 5–18) because of the saturation hypothesis, which implies that more consumption improves wellbeing "but only up to a threshold" (IPCC, 2022: 5–19; Raworth, 2017; Jack, 2022a,b). One might argue that removing hair on faces improves one's wellbeing, for example, if it prevents someone feeling itchy from a moustache. Yet, arguably, the wellbeing benefits of hair removal meet a threshold when we are subjected to constant pressure to remove more and more hair. Like other

[4] A 1.5-Degree lifestyle is a nod to the aspirational target of the Paris Agreement on climate change. This 1.5-Degree lifestyle is defined by Akenji et al. (2021: 13) through "consumption-based accounting, which covers both direct emissions in a country and embodied emissions of imported goods while excluding emissions embodied in exported goods." Overall, it aims to offer some metrics and clarification on the significant lifestyle changes required by high-income countries and wealthier parts of the global population.

wellbeing needs, how these are met will vary by local contexts, cultures, geography, and social preferences, but we suggest that waxing assholes and pubes may have diminishing wellbeing returns and that worrying about being judged for stray hairs has significant negative impact on self-confidence. For example, this 'need' to remove pubes seems to be related to self-enhancement as a sign of beauty and cleanliness but may be motivated more by imagined disgust and rejection from potential intimate partners (Smolak and Murnen, 2011) or the expansion of hair removal to arms, armpits and legs may be more about avoiding imagined shame (Herzig, 2015).

Policy makers are crucial here since they have the tools to address the processes and mechanisms around the marketing of hair removal. It should be illegal for painful non-medical procedures to be marketed by medical professionals. Other opportunities for governments to regulate the growth goal of this industry could be introducing advertising guidelines like those around gambling or smoking that outline risks of these procedures, running hair positivity campaigns, or raising taxes on hair removal devices. By addressing the material, social and cultural elements of hair removal, and parallel consuming practices, policy interventions play a part in bringing us towards wellbeing within planetary boundaries.

5. Concluding discussion: what does Emma do now?

In this paper, we interrogated hair removal as an example of how little activities can add up. This argument can also be made for other consumption domains such as textiles, overseas travel, electrical appliances or energy (yes renewable energy is far better that coal, but using less energy is even better for the environment). Similarly, it's not always about choosing organic cotton over petrochemical produced fibres, but buying fewer clothes completely. Nor is it simply about travelling by train having a lower impact than the car, but bringing in consideration of travelling shorter distances or less frequently.

While hair removal is not a big environmental issue in and of itself, it has proven to be a useful exploration of how to create interventions that target *absolute,* rather than *relative,* sustainability. In the face of the climate emergency, the question is not only whether shaving, waxing or laser is most environmentally-friendly, but also why and how we could stop engaging in resource intensive practices that don't improve wellbeing. Our argument is not that avoiding shaving or waxing or laser is 'the best' action an individual could take to lower their environmental impact, but that even the smallest activities coalesce into billion-dollar industries globally, with attendant billion tonne emissions. And we can question the extent to which these contribute to a decent living standard and where there are diminishing returns on wellbeing, with higher environmental impact.

The history of hair removal in the USA reflects global growth of the normality of hair removal (albeit with some resistance). Hair free armpits, legs, faces and pubic regions further reflect growthism present in many consumption practices. What is the 'goal' or 'meaning' of hair removal? It's hard to pinpoint exactly why we feel compelled here: imagined disgust from potential intimate partners, wanting respect from colleagues, or the worry that being hairy equates with being a scary feminist. It's something that no one really comments on so we do it 'just-in case.' While there have been advances in the tools and techniques of hair removal (e.g., from safety razors that prevented bloodbaths to laser that could cause boils), it's still often painful, time consuming and expensive, yet many people do it and to increasing body parts. Hairlessness is a form of oppression, but we seem addicted to it as self-enhancement and a sign of beauty and cleanliness.

Some would argue that Emma is free to choose, and that we should not restrict choices of young women. The problem with freedom of expression is that it is not free, why else would so many young women (and men) be spending time and money, not to mention putting up with painful (sometimes dangerous) procedures, to become and stay hair free? So what options do we have at our disposal to tackle hair removal, and other mundane consumption inherent in growth intense societies? We've outlined leverage points from Meadows to highlight how LCAs can offer information on where to make changes (e.g., products, use phase, systems thinking wellbeing within planetary boundaries); how to self-organise around normalising hairiness; and regulating so that painful non-medical procedures aren't marketed by medical professionals.

Growthism is the goliath in the room that needs to be tackled. The logics of growth go far beyond wellbeing for people or the planet and in our current economic system there is often little time for reflection about what would actually increase our wellbeing. Instead of trying to do things in the most environmentally friendly way, it's better to do these things less or not to do these things at all. This is in line with much of the degrowth arguments, where the emphasis is on human wellbeing rather than assuming growth is equivalent to wellbeing. Doing less could be a first step in countering upwards trends in time and financial pressure, providing both environmental and psychological benefits.

What if we decided to leave Emma alone? Why do we condition the generation below us to repeat the painful, time consuming, polluting practices that plague us? Let's not leave them with the legacy of (self) oppressive and environmentally degrading practices.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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