Handbook of Leather Design for Sustainable Development

A systemic transdisciplinary approach

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HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
s:ne
SYSTEMINNOVATION FÜR
NACHHALTIGE ENTWICKLUNG

Edited by Jonas Rehn-Groenendijk, Karen Lehmann & Julian Schenten

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UNIVERSITY OF APPLIED SCIENCES

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Editors:
Jonas Rehn-Groenendijk, Darmstadt University of Applied Sciences
Karen Lehmann, Schader-Stiftung
Julian Schenten, Darmstadt University of Applied Sciences

Handbook of Leather Design for Sustainable Development.
A systemic transdisciplinary design approach.

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Leather Product Design Canvas for Sustainable Dev

Material Knowledge

What are all the relevant material options?
Can you ensure sustained supply of these materials?

Appropriateness of Material Choice

What functional or aesthetic properties of the leather are used in your product?
How does the material choice relate to the overall design?
Can leather replace another (less sustainable) material?
Can another (more sustainable) material replace leather?

Business

How can you mak

Type of Leather

Is the type of leather used (tanning process, animal origin, etc.)
appropriate for the products functionality and aesthetics?

Chemicals & Finishing

Did the chemical managament during the production ensure a high level of protection of human health snd the environment?
Does your finishing require specific (and potentially harmful) chemicals?
Is the finishing appropriate to the anticipated usage (e.g. does it lead to a higher usage of chemical protection or caring products?)?

Materials

How can you reduce the total number of materials used for your product?

Legal aspects and business potentials

What are the relevant regulatory frameworks (e.g. EU Green Deal, REACH supply chain due diligence in terms of social and environmental aspects, ...)?
What are working and environmental standards at the locations your are sourcing from?
Can you find business opportunities derived from these regulatory impulses?

Process Optimisation & Waste Avoidance

[Pre-Consumer Aspects]

Does producing your product create unnecessary waste (e.g. from splitting, cutting, etc.)?
Could you adapt the design in a way that producing your product require less harmful chemicals?

Recyclability & Circular Economy

[Post-Consumer Aspects]

What happens with your product after its use-phase?
Can it be easily dissassembled?
Are there collection points and other infrastructure that facilitate recycling?
Can you use (or avoid) specific added materials, chemicals or processes to ensure or increase recyclability?

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Jonas Rehn, Darmstadt University of Applied Sciences | jonas.rehn@h-da.de | Release: October 2021

elopment

Designed by:	Iteration no.
Project:	Date:

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Model

e your business model (more) circular?

Marketing & Communications

How do you communicate so that consumers value how your product fosters sustainable development?
How and how much information on chemicals, working conditions etc. do you share with your consumers?

Who is your Consumer?

What do you know about your target group regarding the usage and disposal of leather products?
What are their values, believes and behavioural patterns?
What do they know about sustainable development with regards to this product?

Sourcing

What is the geographic origin of the hide?
From where does the leather come from (company / country)?
What are socio-economic consequences from sourcing (and not sourcing) the leather from this origin?
Can you establish trustful and sustained cooperations with manufacturers?

Consumer Behaviour Change

How can your design foster more sustainable consumption patterns regarding your product (e.g. maintenance, sharing, repairing, etc.)?
Can your design / marketing strategy increase awareness regarding sustainability issues in the context of leather products?

Traceability

What can you trace regarding the origin of the leather and the chemicals used?
How can you be sure the information you are receiving is valid?
To what extent can you trace back chemicals used in during the production of the leather?

Product Lifespan

How do you extend the product life?
How do you ensure a specific quality level?

Reparability

How can you increase reparability of your product?
Can you help your consumer to repair (e.g. with services or additional products)?

Longevity

How can you extent the product's lifetime? What are the specific technical and conceptual features that make your product more durable?
How aesthetics and emotionals aspects of the design make consumers use your product for a longer period of time?

Product Ecosystem

What is the ecosystem around your product? Can you add or adjust additional products or services to make your product more sustainable?

sformative research project „System innovation for sustainable development" at Darmstadt University of Applied Sciences.

Content

[click on title to jump to chapter]

Photo: unsplash/Ugluk Potroshitel; unsplash/Alexandr Sadkov

1

Guiding Design Processes for More Sustainable Leather Products

Purpose of this Handbook

This handbook aims at facilitating the design and development process of leather products and informing the people working within those processes. They are not intented as formulas to be simply followed in order to create "sustainable products". Instead, the overall goal of this handbook is to broaden the scope of designers, marketers, product managers and all other parties involved in creating new leather products. Leather products are usually embedded in a complex and diffuse system that makes it very difficult to design them "more sustainable". In order to do so, a systemic perspective is needed that takes a wide variety of aspects and interrelations into account that sometimes contradict each other. Therefore, in the case of leather products, design for sustainable development might often be an iterative process involving compromises and uncertainties and requires a constant re-evaluation of design decisions and systemic effects. This handbook is therefore intended to contribute to a capacity-building process through which design and development processes become more systemic, leading towards more sustainable products.

Design usually is (and should be seen as) an interdisciplinary team effort involving, designers, marketers, product managers, engineers, among others. The composition of this design team depends on the product to be designed, the structure and size of the company or consortium in charge, the scope of the design project (e.g. budget, timeline, etc.) and other aspects.

Leather product design for sustainable development therefore requires:

- a systems perspective
- an awareness for rebound- / side-effects
- a willingness to continuously learn and question existing believes
- interdisciplinarity

The handbook aims to contribute to these skills and knowledge.

This document is (a.) a practical advice, (b) research report as well as (c) a transdisciplinary experiment. As opposed to many other design guidelines, playbooks and manuals, it has been created by a team of industry representatives, NGO activists, scientists, leather practitioners and many other people with backgrounds in chemistry, environmental sciences, law, design, economics, leatherwork and more.

As a result, this handbook does not only focus purely on design aspects such as aesthetic appearances, material selection or reparability, but aims at broadening the scope of leather design by including all relevant aspects with respect to sustainable development. Needless to say, this is a continuous iterative and reflexive process of which this document can only be an interim snapshot to help design teams navigate and identify blind spots. By doing so, this handbook serve as practical advice by highlighting key issues and topics without diving too deep into the subject matter. Where applicable, further

reading and recommended sources are mentioned in the text or summarised in chapter 6.

This handbook is also a report on a transdisciplinary research project at Darmstadt University of Applied Sciences. By connecting experts, organisations and general approaches to leather product design, this handbook illustrates the transdisciplinary discourse on leather product design and sustainable development. It points out both critical and controversial positions and methodologies and aims for common ground to practically cooperate in favour of sustainable development in the leather supply chain. Throughout this iterative transdisciplinary process, this handbook went through an number of review phases. Additionally, in summer 2022, a field test of this handbook has been conducted in the form of an international design competition and mentoring program (see p. 217).

Furthermore, applying this handbook to real-life projects represents a transdisciplinary experiment in which design is neither performed by single individuals detached from the production, use and post-use phase, nor exclusively influenced by market research, industry innovations and brand portfolios. Instead, if thoroughly applied, it guides the design process along supply chains and product lives, taking into account economic, social and environmental requirements to foster more sustainable products. At the same time, its experimental and explorative nature lies in its open and flexible structure. It does not prescribe strict formulas, check boxes and blue prints that claim to automatically create the most sustainable products possible. Moreover, this handbook follows the paradigm that sustainable development describes a process. It is a constant attempt to continuously adapt technological, societal and institutional processes to new insights and a systemic understanding on how to maintain and protect life on earth.

For that matter, designing leather products according to this handbook means first and foremost to understand the product's supply chains, ecosystems and entire lifespan. This leads to opportunities to improve existing products or create new products that are entangled in sustainable business models, considering their impact on consumer behaviour as well as pre- and post-use phases. Whether these opportunities are used and more sustainable leather products, services and systems are actually created primarily depends on the design team's skills and rigor as well as the economic and systematic power and responsibility given to them. After all, it is not only the design that makes a product more sustainable, but its actual implementation in corporations, supply chains and the corporate culture that surrounds these processes.

With this being said, we advise design teams applying, students studying and teachers quoting this handbook to look at the bigger picture, to use this document as a guide but not a recipe, and to add the topics mentioned here with their own research and practice wisdom.

How to use this handbook:

- It is recommended to refer to this handbook as a source of knowledge and inspiration to establish a systemic understanding of leather products.
- Chapters in this document shall not be seen as isolated parts but rather elements of an interrelated system that might affect each other.
- As this field is continuously evolving, this handbook is merely a snapshot that might need to be translated to a specific project or updated and complemented by individual research and analysis.
- Design cannot be done by one person alone but rather needs to be a team effort across disciplines. Therefore, ideally, this handbook shall be used by an interdisciplinary team comprising as many roles as possible that relate to the design and development of new leather products (such as sourcing, marketing, etc.).
- Thoroughly design leather products while considering as many relevant sustainability issues as possible is a challenging task. To get the most out of this handbook, it might require a change of corporate culture or mind-set in some organisation, fostering open-minded and transparent communication across departments and disciplines.
- This handbook is not meant to be a set of strict formulas but rather a complex and multidimensional source of knowlegde and inspiration that can be used and re-visited (iterative process) at any stage throughout the design process.

1.1
Project Goals and Methodological Approach

Jonas Rehn-Groenendijk; Julian Schenten

Project Context

The transformative research programme s:ne - Systeminnovation for Nachhaltige Entwicklung (system innovation for sustainable development) at the Darmstadt University of Applied Sciences comprises several projects that aim to contribute to sustainable development with respect to certain societal challenges (energy efficiency, mobility, supply chains). The Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 provide normative orientation.

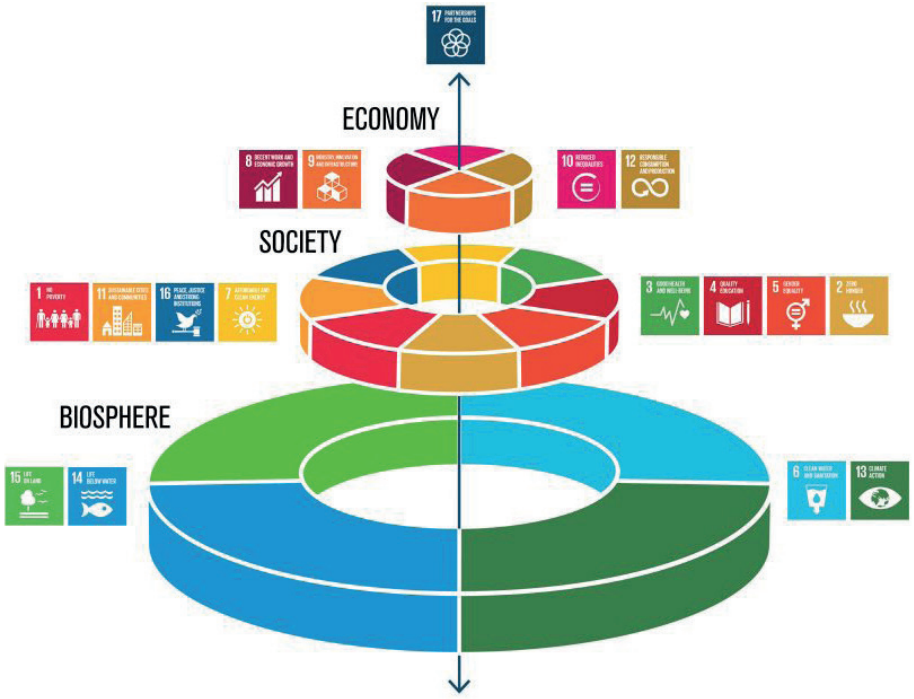

Fig. 1.1.1
A new way of viewing the Sustainable Development Goals. (Azote for Stockholm Resilience Centre, Stockholm University (CC BY 4.0))

Achieving „environmentally sound management of chemicals and all wastes throughout their life cycle" by 2020 - is one specific target under SDG 12. This requires a transformation of production and consumption patterns along global supply chains. Against this background, a project under the s:ne programme is dedicated to the challenges of more sustainable chemistry along the value

chains of leather products. The interdisciplinary team is composed of, inter alia, natural scientists, engineers, lawyers, design researchers and business economists. The mutual exchange of knowledge, experiences and ideas with practitioners is one key element of the project (transdisciplinarity). For this purpose, the University of Applied Sciences Darmstadt has established strategic networks.

More Sustainable Chemistry along the Global Leather Supply Chains and the SDGs

The project's understanding of the concept of "more sustainable chemistry" reflects the progressive character of sustainable development: as research advances and societal values and attitudes change over time, the evaluation of the "sustainability" of chemicals and related processes will change as well. The normative targets enshrined in SDG 12 define the scope of "more sustainable chemistry" for the project. Accordingly, "more sustainable chemistry" strives not to cause adverse effects on people and the environment through toxicity, while not using more natural resources than necessary.

The manufacturing process of genuine leather requires the use of chemicals. Legal requirements and specifications developed by the chemical industry on the careful use of chemicals aim to prevent harm to humans and the environment caused by chemicals. In the modern leather industry, however, global supply chains are the norm, which confronts brands and retailers with enormous challenges: in the control of processes (leather production and processing, other business processes), in compliance activities, and in the ability to actively push the implementation and development of a „more sustainable chemistry" forward among their suppliers.

FOCUS 1: Chemical usage throughout the production process and its effect on humans and the environment

The chemicals used throughout each production step can have adverse effects on humans and the environment in many ways. This applies to the entire life cycle of a leather product - starting at the slaughterhouse, where preservatives are applied to the skin (that is obtained as a by-product), through the various tanning stages up to the shoe factory, for instance. Many of the chemicals are problematic. According to the EU LIFE project BIOPOL, "31% of the volume of the chemicals used by the European leather industry are hazardous substances" as defined by the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). If additional classes of problematic substances not covered by GHS - such as substances with very persistent and very bioaccumulative properties or with endocrine disruptive properties - were added, this share would even increase.

Fig. 1.1.2, left) Non-compliant storage of wet blues in India (photo: SÜDWIND-Institut, 2020)

Fig. 1.1.3, right) When stored properly, residual materials from leather production can be used as e.g. like rabbit chips as starting material for leather fiber products or high quality collagen products. (photo: HELLER-LEDER GmbH & Co. KG)

Processing one tonne of raw hides generates 15 - 50 m^3 of effluent and requires input of approximately 500 kg of process chemicals (Black et al. 2013). While the actual risks depend on the specific process conditions in every tannery, some typical hot spots of chemical challenges in conventional technologies can be described (Buljan and Král 2019, Hansen et al. 2020, Febriana et al. 2012). During transportation and storage, problematic substances such as biocides and pesticides (eg. Fungicides) are applied to preserve raw hides or pre-tanned materials. However, as these substances are expensive to purchase, „household chemical" salt is often used, which also poses a risk to ecosystems if the wastewater is not disposed of properly. Refrigeration as a preservation method is often not possible because of the technical and logistical challenges and the (energy) costs involved. Preservation may also be necessary in the further life cycle during (intermediate) storage of the processed rawhide and the end product. At the pre-tanning and tanning stages, workers can be exposed to irritant substances such as sodium chloride and sodium sulphide. The effluents at these stages comprise high concentrations of salt and cause high chemical oxygen demand (COD) and biological oxygen demand (BOD), which have a sensitive impact on water quality. At the finishing stage, volatile organic solvents may harm workers and nearby residents. In addition, leather often receives coating of per- and polyfluorinated compounds (PFC), which are supposed to make the material more robust. Unfortunately, these substances are highly persistent in the environment, meaning they do not degrade easily and are often toxic. In addition, final products such as leather footwear can constitute a health risk to end consumers, if their skin comes into direct contact with sensitising substances. And finally, at the product's end of life, the question of how to dispose of it in an environmentally friendly matter arises. More details on the role of chemicals in leather making can be found in chapter 3.3.

In terms of SDG 12, resource use is another relevant factor besides toxicological and ecotoxicological aspects. Most of the chemistry used by modern societies is fossil based, and so is leather chemistry. Chrome tanning is based on a mineral that is extracted from mines. Vegetable tanning uses renewable resources, but their cultivation can take up significant amounts of land and water. Furthermore, the different tanning systems require specific inputs of energy and water. This brief overview shows the relevance and complexity of resource use in leather manufacturing, and the chemical raw materials needed during the product's life cycle.

More Sustainable Consumption and Production Patterns

With regards to SDG 12, this handbook goes beyond the scope of more sustainable leather chemistry. In particular, in the context of leather products, there are a number of parameters that are relevant to fostering more sustainable consumption and production patterns. As illustrated in chapter 2 and chapter 3.1, leather possesses properties such as its durability, repairability and its cultural heritage that can serve as an ideal basis to extend product lifetime and facilitate reuse. If this is addressed properly by the design team and communicated and marketed accordingly, leather products can become more sustainable.

These more sustainable products require the use of less harmful chemicals, have traceable and to some extent transparent supply chains, and their conceptual design makes it easier to repair or exchange parts. Materials such as the type of leather are chosen according to the actual use case of the product to ensure its durability. Addressing consumer desires and their emotional attachment to the product, more sustainable leather products influence consumer behaviour in so far as they are taking care of the material, are willing to invest in repair and recognise the value of a second or third life for the product. They may even appreciate irregularities and signs of aging as visual representations of a natural and unique material.

All this can support new (circular) business models, reduce environmental impact and change the way leather chemistry is applied. More sustainable consumption and production patterns will eventually also mean that leather is no longer used as a material for use cases for which it is not suitable for (e.g. fast fashion concepts).

While the project has its focus on SDG 12, this should not neglect the relevance of other SDGs as well. Rather, by promoting activities contributing to SDG 12, co-benefits with regard to other targets related to human health (e.g. SDG 3), the climate (SDG 13) and nature conservation (e.g. SDG 15) are to be expected (Le Blanc 2015). Additionally, in the course of the project the discussions with actors have shown that the concept of a "more sustainable chemistry" along global leather supply chains does not have to be limited to health and

environment aspects. At the same time, the social status and well-being of the participants along the supply chains, i.e. workers in the various facilities, constitute challenges of sustainable development on their own behalf (see focus box 2 and focus box 3). That is why the project activities and outputs, such as the handbook of leather design, strives to unlock positive impacts on social aspects as well.

Focus 2: SDG 8, Decent work and economic growth

by Jiska Gojowczyk & Pradeepan Ravi (extract from Gojowczyk & Ravi, 2022)

SDG 8 on decent work and economic growth includes target 8.8, which aimes at "protect[ing] labour rights and promot[ing] safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment". Target 8.3 includes "decent job creation and [... the] encourage[ment of] the formalization and growth of micro-, small- and medium-sized enterprises"; informal employment should be reduced. [...]

Pandu (2018) has looked at the perceived quality of life of leather workers in India and found that occupational health and safety and the atmosphere at the workplace are critical. Sarkar/Akter (2018), focusing on Bangladesh, and Grumiller (2021), Grumiller/Werner (2019) and Hardy/Hauge (2019), all focusing on Ethiopia, are among the few academic findings that specifically shed light on the workers' situation beyond health concerns and discuss problems such as very low wages, missing bargaining power and short-term employment in the sector.

Given the academic gap, various field studies and publications by civil society organisations have revealed the problems which need to be addressed to transform jobs in the leather industry to be "decent". Problems identified include severe labour rights violations such as restrictions on the freedom of association and the right to form trade unions and to bargain collectively. Furthermore, forced overtime, harassment, discrimination and violence in the workplace, as well as legal uncertainties due to lack of or inadequate employment contracts (cf. e.g. CYS 2021; Williams/Brill/Ravi 2019; Public Eye 2017; also on problems in footwear production and intersectionality of discrimination). Especially in poor countries, the leather and leather goods sectors are a livelihood for millions of people. Many of them belong to vulnerable groups which are socially and economically marginalised due to their gender, caste, citizenship or cultural identity (cf. e.g. Hoefe et al. 2017[1]).

The US Bureau of International Labor Affairs (ILAB)'s 2020 List of Goods Produced by Child Labor or Forced Labor identifies the risk of child labour in leather and leather goods production in Bangladesh, India, Mexico, Pakistan, and Vietnam. For the related footwear sector, the risk of child labour is also identified for Brazil, Indonesia and Turkey; forced labour is documented for China. However, it is well known that exploitative practices are not limited to these countries, as awareness for this issue among industry participants and auditors has increased as well (cf. e.g. Sebastio 2021). So far, however, there has been no open and transformative discourse about these concerns in the industry. On the contrary, it is very likely that the Covid-19-pandemic has worsened the situation for workers in the countries mentioned and many others.[...]

Research on global value chains has recently given answers on underlying causes which complicate the creation of decent work. It has become a common understanding that economic power imbalances between buying brands and suppliers, and related poor purchasing practices and business relations, often leave suppliers little choice but to agree to excessive time and price pressures, some of which are passed on to the workforce and/or prior tiers (cf. e.g. Anner 2019).

Focus 3: SDG 1, No poverty

by Jiska Gojowczyk & Pradeepan Ravi (extract from Gojowczyk & Ravi, 2022)

SDG 1 aims at the end of poverty in all its forms. Following target 1.1, by "2030, [...] extreme poverty for all people everywhere [shall be eradicated], currently measured as people living on less than $1.25 a day" (UN DESA 2021c). Target 1.5 states:

> **By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.**

The COVID-19 pandemic with its multi-dimensional consequences in most countries of the world has surely been such a shock. We will use this shock to exemplify how SDG 1 relates to business activities in the leather industry. In the summer of 2020 when COVID-19 hampered business globally, we conducted a survey with shoe and leather workers in India, as one important production area for the world market. That survey clearly showed their vulnerability.

In our research together with colleagues from Society for Labour and Development India (SLD) and INKOTA, we interrogated 115 workers, encompassing 37 different shoe production sites and 18 tanneries, in the areas of Vellore (Tamil Nadu), Kanpur and Unnao (Uttar Pradesh) in India. We brought to light how the COVID-19 induced crises caused huge income and job losses, financial insecurity, and acute shortage of basic supplies for workers. The survey showed how even workers who had been working in the industry for decades experienced a high risk of long-term impoverishment.

The pandemic had of course challenged the leather sector worldwide. The Indian shoe and leather industry, for instance, experienced supply bottlenecks, factory closures during a hard lockdown ordered by the government (March to June 2020), lack of cash-flow, and the crash of national and international demand. However, our research shows that the actors with the weakest financial, political, and legal position in the value chain - the workers - took on a disproportionately high burden in this situation, while other actors used their options to refuse shared responsibilities.

During the hard lockdown, more than a third of the sample of workers was confronted with total wage loss. More than half was forced to take on debt. Nearly 40% of the sample was

not able to take up work when the production sites re-opened in June 2020; while 22% of the sample found work but earned less than before. Those workers who earned comparably decent wages before the pandemic (though still not at the level of living wages as calculated by the Asia Floor Wage Alliance, AFWA) accounted for the income group facing the greatest wage losses. The worker group getting the same wage before and after the hard lockdown were mainly those with extremely low wages, with many of them being women. We also learned that many workers could not access social security systems during the crisis, an important reason for this being their informal or insecure employment statuses. Furthermore, in many workplaces, workers councils or trade unions did not exist or were not consulted by their respective factory or tannery management to negotiate each actor groups' needs and to find solutions (Gojowczyk 2021; Ravi 2020; Wazed 2021). Media coverage, personal accounts of workers, industry statements in 2020 and 2021, and reports by international organizations on manufacturing industries (such as International Labour Organization 2020) give reason to assume that India's situation is no exception among other leather production countries.

With their low wages before the crisis, workers could hardly build up reserves; and in the crisis, they did not have the necessary political, social, and economic means to defend their interests in international value chains. In this respect, they are the victims of merciless international competition for the cheapest production. This competition is the direct result of the demands formulated by the strongest players in the market financially and the fact that governments, until today, do not use regulation, tax, and financing mechanisms well enough to support sustainable and inclusive business investment in the industry.[...]

Transdisciplinarity as a Synergetic Asset

The development of this handbook as part of the broader research project on more sustainable leather supply chains is based on the assumption that innovation in complex systems can most effectively be achieved by participatory processes involving most of the relevant stakeholders (Belcher et al., 2019). This mix of different professions, academic fields and public agents goes beyond disciplinary boundaries and aims at establishing common ground for stakeholders to engage and negotiate based on a shared goal.

Many of the challenges in the context of sustainable development require close collaboration of industry, academia, public agents and other stakeholders. In many cases, single technological innovations or isolated regulatory changes will not have a sufficient impact on the broader system at hand. This project therefore follows the idea of socio-technical systems (Geels, 2002), in which technological elements are inseparably linked to individual and societal processes.

Therefore, as opposed to many other guidelines and manuals on sustainable design, this handbook has not been written by the industry or the academia, but has been created in an iterative co-creative process. It represents the

output of an iterative transdisciplinary process that comprises a number of stakeholders from industry, academia and civil society, a process based on discussions, workshops and negotiations where both insight and compromise had to be to be achieved in order to agree upon a statement made in this document. In this way, transdisciplinarity also refers to processes that lead to compromises and an agile approach. This handbook is one step on a path towards more sustainable (leather) products. Needless to say, they have to be subject to change and revisitation as new insights and developments occur.

Finally, transdisciplinarity also includes the evaluation of this handbook. Although the mere development of this document is the result of negotiation, communication and, by that, also an increase of awareness for a systemic perspective, this handbook needs to be applied and tested in real life processes. In close collaboration of industry, academia and other parties involved, this handbook can be refined and thus become more effective.

Research-based and Evidence-based Handbook

This handbook follows both a research-based and evidence-based design approach. By using several empirical research methods such as focus groups, surveys, various types of interviews and desk research, insights were gathered and tacit knowledge was made available. Especially in the field of leather and leather product design, there is a huge body of knowledge hidden in the daily routines of experts in the field, as well as ancient skills and know-how that is nowadays hardly considered. Both sources pose a highly useful asset for design for sustainable development.

In line with this, we follow the assumption made by Visocky O'Grady and Visocky O'Grady (2017) that a rigorous and creative use of empirical methods can strengthen design processes and foster more effective concepts.

Furthermore, whenever appropriate and possible, methods, facts and strategies are based on current best evidence from a wide range of fields including leather chemistry, consumer psychology and design science. By doing so, this handbook can contribute to the field of evidence-based design (EBD) as proposed by Hamilton (2003) and more broadly defined by Hamilton and Wadson (2009):

> „Evidence-based design is a process for the conscientious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project."
> (Hamilton and Watson, 2009: vii)

This design paradigm derives from the field of architecture and is rooted in the idea of evidence-based medicine. EBD advocates the use of scientific evidence in design projects to strengthen effectiveness and avoid unwanted side effects.

While EBD is particularly successful in the field of design for health, it can also be applied to the notion of sustainable development. Considering the tremendous complexity and interdependency of challenges regarding sustainable development, classical product design depends on rigorous evidence to actually create more sustainable products. However, EBD should not be misunderstood as a strictly formulaic approach in either architecture or design, dictating design decisions based on scientific studies. In contrary, EBD embraces the design team's experience and tacit knowledge and aims at complementing it with additional evidence to foster the best possible results.

With regards to more sustainable leather products, applying EBD must be seen as a starting point that considers evidence from various relevant fields that to some extent relate to the project at hand. Thus, a holistic and systemic point of view is needed that goes beyond disciplinary boundaries to anticipate the actual effect a specific product or a particular design decision can have in terms of sustainable development.

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1.2
Conceptual Background of this Handbook

Jonas Rehn-Groenendijk; Julian Schenten

The transformative research project follows a transdisciplinary approach (Belcher et al. 2019) aiming at system innovations for sustainable development. It is based on the assumption that to transform complex socio-technical systems, such as the production and consumption of leather, key actors have to cooperate. In a scenario building process (March – June 2019) based on methods by Geschka et al. (2008), a transdisciplinary team (including representatives, inter alia, from civil society, chemical and leather industries, brands as well as research)[1] developed scenarios for the topic "Leather 2035". Scenario building is an exploratory process empirically substantiated by the inputs of the participating experts from the field. This process first facilitated the creation of a common problem understanding among all actors. In the end, the team agreed on a vision by committing to work towards an optimistic scenario narrative telling the story of how in 2035 more sustainable leather chemistry will have emerged[1]. In this narrative, increased transparency about the chemicals used in the global supply chains and their effects on humans and the environment as well as related knowledge of supply chain actors and the general public are major factors of influence (cf. figure 1.2.1, next page)

[1] Scenario story available as PDF here: http://bit.ly/leather2035

Subsequently, we hosted transdisciplinary strategy workshops to identify specific short-term and long-term actions to attain to the 2035 scenario. The results of these workshops were further elaborated into a Theory of Change (ToC) for more sustainable leather chemistry (Schenten and Rehn 2021), cf. figure #2, i.e. a tool to design („roadmap") and monitor system innovations (Deutsch et al. 2021).

[1] The following organizations participated in the process: Stahl Chemicals Germany GmbH, HELLER-LEDER GmbH & Co. KG, Deichmann SE, Tchibo GmbH, Triaz GmbH (with the brand "Waschbär"), Verband TEGEWA e.V. (Association of Manufacturers of Process and Performance Chemicals), Verband der Deutschen Lederindustrie e.V. (VdL; German Leather Industry Association), Verband der Automobilindustrie e. V. (VDA; German Association of the Automotive Industry), Prüf- und Forschungsinstitut Pirmasens e.V. (PFI; Materials Testing and Research), SÜDWIND e.V., Öko-Institut e.V., Consulting Service International Ltd and the Darmstadt University of Applied Sciences.

Figure 1.2.1: Factors influencing how leather will be manufactured in 2035, according to the scenario narrative

Based on this Theory of Change (see fig. 1.2.2, next page), four subprojects were iteratively developed and reviewed by representatives along the leather supply chains. These subprojects aim for specific outputs that foster systemic process in line with this theory leading to the optimistic scenario narrative described above.

While each subproject focuses on another relevant aspect for transforming the leather supply chains, they are interrelated with each other and potential synergies between them are constantly investigated and implemented.

One of these subprojects dealt with the development of the herewith presented design guidelines. With regards to the before mentioned Theory of Change, the systemic purpose of this document is – among other things – to change product development processes. Furthermore, regarding consumption patterns, these guidelines should also set impulses to raise consumer awareness and create

product and information services. In a broader sense, they should support process innovations in favor of sustainable development and improve vertical and horizontal collaboration while building capacity in production countries. Needless to say, these guidelines can only contribute on a small scale to these complex and long-term processes. However, they are meant to be a first step towards a broader transformation of the leather supply chains.

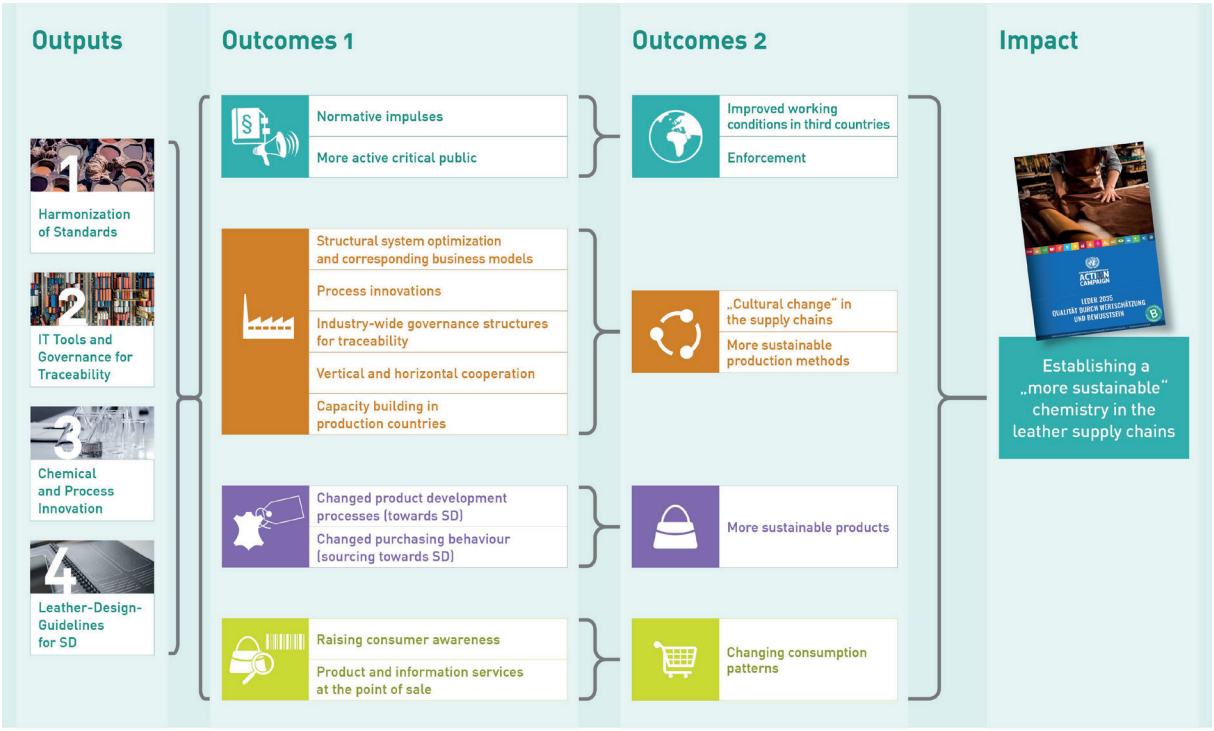
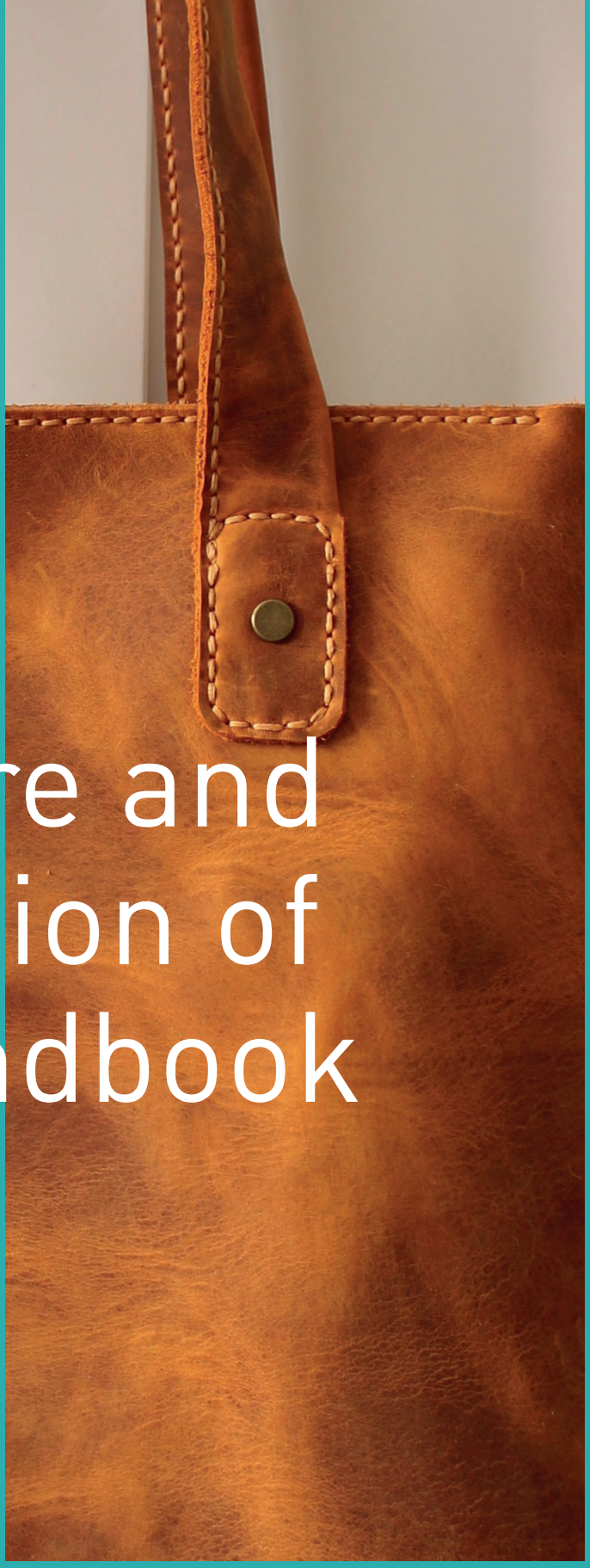


Figure 1.2.2: Theory of Change for a more sustainable leather chemistry

2

Structure and Application of this Handbook



Unlike many other handbooks, this document addresses not only a complex as well as controversial topic (i.e. strategies to foster sustainable development) but also targets a heterogeneous group of readers. Chapter 2 aims to provide a clearer picture of the goals and the approach of this handbook and to structure and elaborate on important terms.

The Two Elements of Sustainable Development and Leather Products

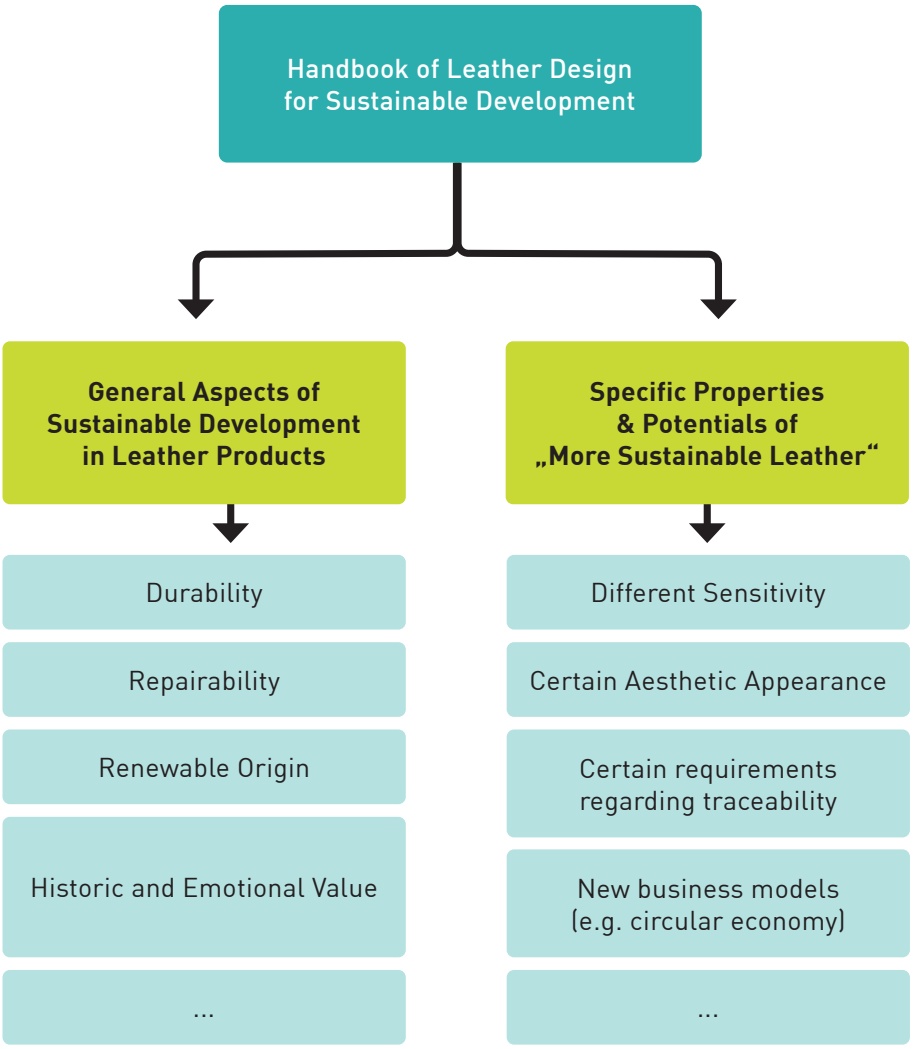


Fig. 2.1) Two streams of sustainable leather goods

Leather is a complex material with many subcategories regarding the type of leather, tanning processes applied, the hides used and many other aspects. When leather is used in products such as shoes, bags and furniture, this complexity is further increased by design decisions regarding the joining of materials (e.g. using adhesives and stitching) and more (see chapter 4).

In a wider sense, there are two overarching perspectives according to which leather products can be designed and produced in a more sustainable way (fig. 2.1).

General Aspects of Sustainable Development in Leather Goods

Leather by default offers potentials to make a product more sustainable in contrast to synthetic leather or other materials. These potentials relate to the genuine characteristics and functionality of the material leather. For instance, the process of tanning aims at conserving raw hides and making them durable. In this way, when processed according to the state of the art in leather manufacturing, leather can be considered as a long-lasting and easy to repair material, which makes a good material base for the design approach regarding longevity (see chapter 4.1).

Furthermore, based on the current global consumption patterns regarding meat and dairy products, leather is made from renewable resources in contrast to materials that are based on fossil chemistry, for instance. However, this advantage depends on the structure of the global supply chains and consumption patterns and might change, as demonstrated in the vegan movement in many western countries.

In addition to that, the ancient history of leather and the cultural practices associated with it established a comprehensive collection of associations, values and emotions linked to this material. While these associations differ between cultures and individuals, they offer potentials for design strategies such as product attachment (see chapters 3.8 & 4.1) and support the notion of luxury and value that is still associated with this material today.

All these general aspects need to be considered throughout the design process to be effective and add value in terms of sustainable development. In contrast, aiming at cheap fast-fashion leather goods might be economically beneficial for companies from a narrow business perspective, but are not compatible with the genuine characteristics of leather as a durable and repairable material. However, appreciating these material properties offer new economic potentials that might lead to different but more sustainable business models (see chapter 4.4).

Specific Properties and Potentials of “More Sustainable Leather”

As of now, there is a controversial discourse about the term “sustainable leather” and the proper definition of this term. While this handbook does not aim at defining this term, it might as well summarise key aspects and concepts related to what could be called “more sustainable leather” (see chapter 2.4).

This being said, “more sustainable leather” might differ from “conventional leather” in terms of chemicals used, traceability of hides and chemicals (chapter 3.5), working conditions and transparency throughout the supply chains and towards the consumers (chapters 3.8 & 4.5). Especially with regards to the use of specific chemicals and the avoidance of certain unwanted chemicals and processes (e.g. tanning agents or finishing layers), “more sustainable leather” might have specific functional and aesthetic characteristics.

Among other things, these differences affect possible areas of application and related requirements (e.g. material care). One example is the resistance to environmental influences such as UV-radiation, mechanical friction and moisture. Although more sustainably produced leather seems to be more sensitive in this respect, the changeability and ageing of the material can be seen as an aesthetic (cf. patina) or even functional unique selling proposition (USP).

However, “more sustainable leather” requires an appropriate design and use that takes advantages of its particular aesthetic features (e.g. similar to stone-washed jeans) as well as target group-oriented marketing instruments. Design and the associated selection and sourcing of materials are inseparably linked to topics such as consumer behaviour, particular material properties, areas of application and business models. Considering insights, derived from these topics, throughout the design and development process can be useful in terms of sustainability and offers new marketing potential. In addition to the use and processing of „more sustainably“ produced leather, this potential also extends to business models, for example those related to product-service systems (PSS; see Waidelich et al., 2019; see also chapter 4.4). Examples of PSS could be products that are supplemented by services (e.g. maintenance service) or products that are marketed as services (e.g. shoe leasing).

Structure of this Handbook

This handbook are divided into two main parts. In the first part (Chapter 3) the real world context of leather design ist presented. This is intended to provide a knowledge base on which design decisions can be made. Professionals with an expertise in one of these chapters might skip this part. However, throughout the chapters in this handbook cross links will continually refer to this overarching knowledge part.

The second part (Chapter 4) covers design aspects that usually should be considered throughout a design and development process for leather products. Building on the basic knowledge of chapter 3, this part deepens the understanding for leather as a material and its application in consumer products. This chapter also refers to general design approaches that do not

necessarily derive from leather product design. Moreover, it includes a set of design methods and paradigms that focus on specific design goals that are in line with sustainable development. This chapter might as well be applied to other product categories.

Apart from these two main parts, chapter 5 contains a list of design methods that are mentioned throughout the handbook. It also comprises a manual for the leather product design canvas, which is an easy to use tool to explore and improve design concepts with regards to sustainable development

At the end of this handbook, a list of publications for further reading (and watching) can be found in chapter 6. This chapter also contains a list of all authors and organisations that have contributed to this handbook.

2.1
The Role of Design of Leather Products for Sustainable Development

Jonas Rehn-Groenendijk

A brief Definition for Design in the Context of Leather Products

There are only few terms that are used as inflationary as the term "design", which led to an overwhelming and often misleading number of definitions. In everyday life, people usually use the word "design" when they refer to the aesthetic appearance of an object or a digital product. In many cases and especially in the context of fashion and leather products "design" is almost synonymously used for "style".

However, in both science and practice, "design" comprises usually a complex and overarching concept that refers to all aspects and issues related to the development of a product or system. In the context of this hanbook of leather design and in respect of leather products the term "design" is used to summarize all the steps and aspects that aim at creating new or improving existing products and services. This includes not only aesthetic decisions such as proportions, colour, sizes and material selections, but also procurement, as this defines specific attributes of the product (or even related information such as working conditions or toxicological aspects; see also chapter 3.5). Therefore, this more comprehensive understanding of design of leather products is based on an extended scope beyond the mere product and takes product and business ecosystems, packaging and end-of-use scenarios as well as consumer behaviour, supply chains and traceability into account. At the same time, typical product design aspects are of equal relevance. Furthermore, manufacturing processes have a huge influence on pre-consumer recyclability, waste avoidance and other environmental and social issues (e.g. see chapter 3.1 & 4.3). While selecting the appropriate materials is always a key element in product design, this is of particular importance with regards to sustainable development as it relates to a number of aspects such as post-consumer recyclability, reparability, durability and much more (see chapters 4.1 - 4.5).

This broad definition for design is not a blurring version of its original definition, but a genuine systems perspective. This is because all design

decisions (including styles) will affect other processes and aspects in the broader context of what is to be designed. Including these mechanisms and effects in the design process means understanding the interrelation and interdependencies of design on a systemic level. With regards to sustainable development, this perspective is crucial.

Therefore, design in the context of this handbook includes the design of
... leather products
... leather (with regards to its aesthetic and functional features)
... marketing strategies and communication efforts
... business models and services
... (product eco-) systems
... and much more

Similar to the often unclear definition of the term "design", the role and skills of "designers" can greatly differ depending on one's profile. For example, in some fields or projects a rather technical designer is needed to creatively apply the rules of engineering and physics to design concepts that both innovative and practically implementable. In other cases, the role of the designer is focused on the formal-aesthetic appearance of a product while others are tasked with translating this concept into material decisions, producible parts and constructions. Needless to say, this dichotomous description is a simplification which might define a continuum in which every designer could be located. However, there will be hardly any aesthetic-driven design decision without some kind of material and construction focus. Also, technical design decisions affect the overall look and feel and are therefore usually considered from an aesthetics point of view as well.

With regards to leather products in general and this handbook in particular, instead of focusing on the role of the designer, the role and skills of the design team might be a more applicable concept. Designing more sustainable leather products involves a complex mix of theoretical and practical knowledge and skills that can hardly be obtained by one person alone. Rather, interdisciplinary teams of creative and open-minded experts applying this handbook based on their shared knowledge will achieve the most sustainable outputs. As in many other industries, the designer's role among others could be to facilitate, moderate and communicate the process translating ideas and results into product features and design aspects.

Aspects of Design and their Relation to Sustainable Development

When designing products or services (e.g. leasing services as a product-service-system for fashion items), the decisions and considerations in this process will greatly influence the way this product will be produced, how many

resources will have to be used and how users will interact with this product. From a systemic perspective, there is hardly any design aspect that does not relate to aspects of sustainable development. Understanding these relations is therefore important when aiming at creating a positive impuls for a specific system such as the leather supply chains.

The herewith proposed handbook of leather design aims at supporting systemic understanding in the field of leather product design and building capacity for more sustainable practices. At the same time, the field of design is constantly moving and developing. Therefore, this handbook can only outline certain aspects to be considered and to broaden the reader's horizon to start an ongoing learning process.

Most important in this process is a humble-minded approach. Designers and all other parties involved in developing new products need to constantly reflect and evaluate their work and the results of their work with respect to sustainable development, aiming to better understand effects and consequences of certain design decisions and to gain insights on new opportunities derived from disruptive design approaches.

Changing one type of leather for another or replacing a specific coating for another can have multiple consequences including different supply chains, reduced use of resources and changed consumer behaviour. In many cases improvements in one field might have side-effects ("rebound-effects") in another. For instance, one might argue to avoid the use of plastics as a coating for leather (e.g. Polyurethane) due to ecological damages during production, use (e.g. microplastics) and at the end-of-product life. Focusing on this single design aspect without a systemic understanding of design necessities that emerge out of this decision, the final product might be simply less durable, requiring consumers to use hazardous chemicals to protect the surface of decreasing the product's lifespan. Needless to say, there are ways to replace PU-coating but in some cases this might need to go hand in hand with stimulating specific consumer behaviour regarding maintenance of the product or changing consumer's expectations with respect to the product's appearance and resistance to certain environmental impacts.

Design can also be used to change (consumer) behaviour (e.g. maintenance of products) or to promote buying behaviour that aligns with sustainability values (see chapters 3.8 & 4.5). With regards to service design and business model design, concepts might also allow consumers to make decisions that they could not do with conventional designs, like being able to send back a shoe free of charge to a company with repair services via an integrated QR code in the shoe. Thus, a holistic understanding of design that integrates business models could allow new customers to buy a product that would usually be too expensive (i.e. renting / leasing of high priced products) (see chapter 4.4).

Role of Design and the Design Team

However, sustainable development is a highly complex field that comprises a number of challenges that might be called "super wicked problems" according to the definition proposed by Levin and her colleagues[1]. Designers of leather products are usually faced with contradicting targets. While the fashion industry demands continuously new styles and approaches that often follow a business model of planned obsolescence, aiming for more sustainable leather products might require to create concepts that have a profound impact on many other departments of a company than product development such as procurement, quality management, business development, marketing etc. Understanding the significant role design might have to create more sustainable products and consumer behavior, it requires a paradigm shift that puts design decisions in the core of strategic management. Therefore, design cannot be done by one person alone but rather needs to be a team effort across all disciplines.

There are a number of incentives and obstacles regarding the design of more sustainable leather products. On the one hand, sustainable development currently re-experiences a rise in popularity fueled by initiatives such as Fridays For Future and the rising awareness for the climate crisis. On the other hand, globalised industries and highly competitive markets put a lot of pressure on brands and retailers to reduce prices and increase revenue streams - sometimes even by applying greenwashing campaigns. For this reason, this handbook is not only adressed to designers, but to all relevant actors and aspects in the field of leather product design. By doing so, the designer's role is not only to apply the knowledge and principles outlined in this document but also to facilitate and reinforce processes, discourse and collaborations in industry and society that favour sustainable development. Thus, design as a process and methodology and its outputs in the form of products and services can be seen as an impulse that might affect both industry and society.

[1] see Levin, Kelly; Cashore, Benjamin; Bernstein, Steven; Auld, Graeme (2012): Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. In: Policy Sci 45 (2), S. 123-152.

2.2
How to use this handbook

Jonas Rehn-Groenendijk

The Role of Handbooks and Guidelines in the Design Process

Design guidelines usually are tools that are meant to support the design process. They provide a framework in which creative and innovative processes can take place while establishing a specific design paradigm. In this sense, this handbook is no set of strict formulas or recipes, but impulses to broaden one's horizon and deepen one's knowledge when designing leather products with a focus on sustainable development.

As stated before, this handbook is the product of an iterative transdisciplinary process involving a number of different stakeholders along the leather supply chains as well as academia. The result is a broad and multi-perspective document that draws attention to various aspects that should be addressed when designing leather products. Advice and impulses written here are based on practical knowledge from professional experience or evidence-based. As both sources of knowledge evolve and change over time, readers are recommended to question all approaches and concepts stated in this handbook based on their own knowledge and the latest available evidence.

While each project differs in terms of product category, market segment, budget and more, this handbook is written in the attempt to cover as many relevant product categories and design cases as possible. However, by doing so, more in depth information on specific leather product categories (technical aspects leather shoes or car seatings) has been excluded and should be looked up elsewhere.

As design usually is an iterative process, this handbook can be used at any point throughout a design process. However, it is recommended to make use of the information provided here as early as possible to increase impact and reduce potential added costs due to delayed design adjustments. If early use of the handbook is unlikely due to time or budget limitations, we advise referring to the Leather Product Design Canvas in chapter 5 for a brief overview of relevant topics and approaches.

Although this handbook refers to leather products specifically, some of the approaches and paradigms apply to other product categories as well. This holds true especially with regards to the systems perspective proposed here. As sustainable development poses complex challenges, designing products and services that support it must be based on a broad understanding of interdependencies and potential rebound effects of certain design decisions.

Design Handbook for Designers and Non-Designers

This handbook has been developed based on the assumption that a successful design process in favor of sustainable development requires team efforts that go beyond the classic role of a designer. Therefore, this document is written both for designers and non-designers working in the field or supporting the process of design. The information in this book is provided in a way that does not require specific prior knowledge or design expertise. On the contrary, by covering a wide range of different topics, this handbook aims to highlight the complexity of the field of leather product design and give impulses to strengthen interdisciplinary team work in order to foster synergies and increase individual knowledge and skills.

Although readers may apply this handbook in very different use cases, we recommend at least the following three examples for which this handbook can be useful:

1. Use for general capacity building and sensitisation

The field of leather product design is complex and comprises a number of aspects that need to be considered when creating more sustainable products. In many cases, people involved in the design process are specialists for specific elements (e.g. designers, marketers, product managers, etc.) but might lack a comprehensive understanding of the bigger picture and potential opportunities of their design task. Therefore, this handbook can be a starting point for capacity building in organisations or educational institutions. Although they only briefly elaborate on the aspects mentioned, this handbook aims to help navigate through this complexity and find further readings. By doing so they can offer a profound overview of relevant topics and aspects that might be revisited by additional literature or other sources[1].

[1] for some recommendations see chapter 6

2. Use for specific projects and products

As every project is unique, challenges and questions may arise that require systemic understanding or creative impulse to foster more sustainable results. This handbook can be used as a tool to dive into specific topics (e.g. innovative business models - chapter 4.4 or considering the cultural value of the material - chapter 3.7) to find inspiration and knowledge for the project at hand. In some cases, this might even be helpful for troubleshooting regarding specific sustainability challenges.

3. Use as a general reference

With respect to the aforementioned use of this handbook, they may also be helpful in the day-to-day working context when it comes to supporting and structuring the design process or ruling out blind spots that should be considered from a sustainable development point of view. Thus, they can feed into global design strategies and help in formulating design briefings to cover a wider range of aspects regarding more sustainable leather products.

Limitations of this Handbook

It is worth mentioning that this handbook does not aim to cover all relevant aspects when designing leather products. Moreover, the topics covered in this publication are merely touched on in order for readers to dive deeper into them when relevant to their respective task or project context.

As leather is a controversial material and supply chains usually are complex and diffuse, some recommendations and impulses might appear conflicting to each other. This however is the nature of this topic, as decisions may improve upon one issue while creating adverse effects elsewhere. So a careful balancing of the differing requirements is needed. In this sense, following this handbook does not automatically lead to more sustainable leather products but will lead to the "right questions" to be answered in order to create more sustainable leather products.

Furthermore, as the field of leather technology and product design is constantly evolving and both new technologies and new scientific insights emerge, this handbook should be seen as a snapshot in time with regard to the design of leather products, which will need to be adapted and extended according to the state of the art in these fields.

2.3
Framework of Leather Design Methods and Approaches for Sustainable Development

Jonas Rehn-Groenendijk

Based on the insights of a number of co-creation workshops with representatives of the leather supply chains and related fields, the proposed framework is one possible way to structure the complex and dynamic field of design for sustainable development in the context of leather products.

This framework is built from a table comprising two axes (fig. 2.3.1). The y-axis describes general aspects and perspectives of the design process. While in some cases the boundaries between aspects may be blurred, they represent issues that typically need to be considered when designing a product and a service. The X-axis comprises four design strategies that refer to sustainable development. Although they do not specifically refer to leather products, they are applicable for this product group in particular. At the intersections of both axes specific design methods and techniques can be allocated. In some cases, design methods may refer to several links.

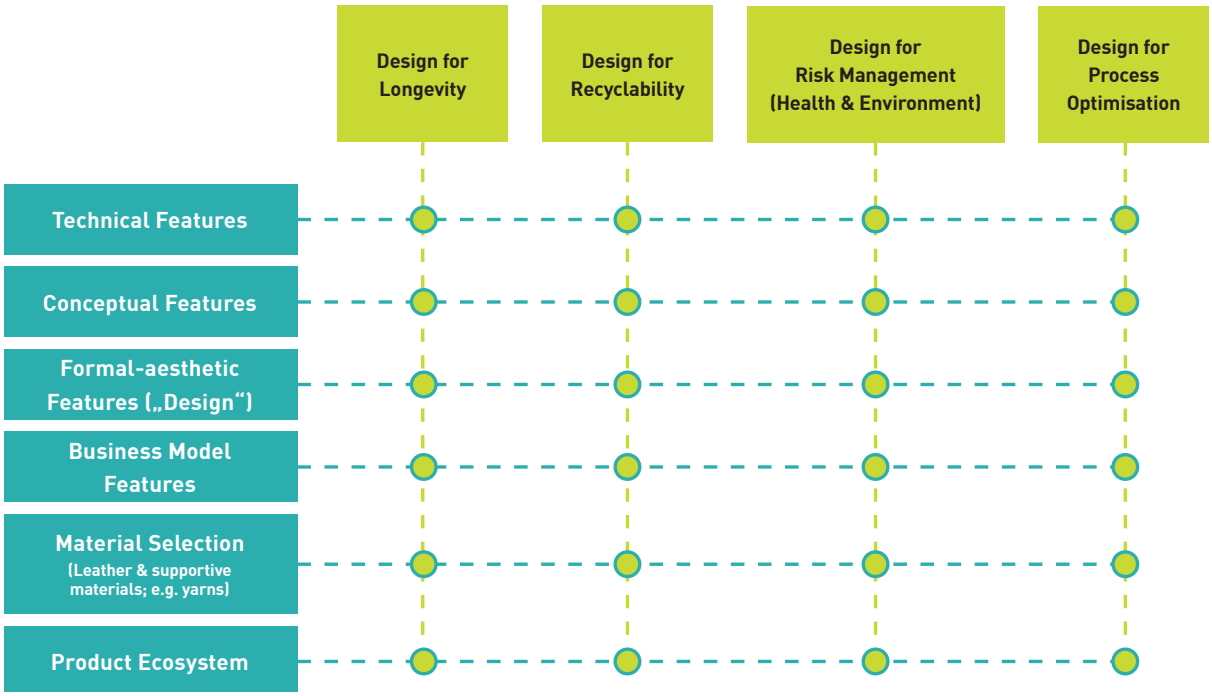


Fig. 2.3.1) Framework of Design Methods

This framework is supposed to be seen in an iterative manner as an open concept that can be adapted and extended by new insights. In combination with the Leather Product Design Canvas (Chapter 5.2) it can help gain an overview of relevant aspects and potentially useful approaches. Design teams aiming for specific impact related to one of the four design strategies of the X-axis can go through the six general aspects of the design process to develop ideas and explore specific design measures.

General Design Aspects (Y-axis)

The six design aspects mentioned here are rough simplifications of the complex process of designing. They are only intented to help structure and guide potential design measures. We are fully aware that these categories might overlap and influence each other.

Technical features

Technical features are elements and properties of the product or product-service-system that refer to technical functioning (e.g. connections, material properties, coatings,...). Although this is directly linked to other aspects such as formal-aesthetic features, this category focuses on the technical element within. For example, while the use of stitching to join pieces of leather strongly influences the overall appearance of a product, in this category it is only relevant that stitching requires a specific working method (the stitching process), technology (a special sewing machine and thickness of yarn and leather) and offers particular options (e.g. easy disassembly by cutting the yarn).

To categorise and elaborate on the design process of leather products one could start with its technical features. As opposed to aesthetical qualities or conceptual approaches of a certain design, technical features are design decisions that relate to functional aspects, such as the way materials are joined, the type of tanning agent used or the finish applied to create a specific surface structure. Although technical features cannot be separated from their aesthetics or the conceptual design they are derived from, it is recommended to use this category as a lense through which one might analyse a product or concept - especially with regards to sustainable development.

Needless to say, there is a wide range of leather products for consumers such as casual shoes, bags, wallets or car seats. Depending on the functional requirements and production methods, entirely different technical aspects need to be considered and different technical options are available. The following compilation summarises this in a rather generic way that needs to be adapted according to the project and product category at hand.

Joining leather

Unlike many plastic products or even 3D-printed items, leather products are usually made from several pieces of leather and other materials that need

to be joined together. This connection can be either between (a.) leather and leather (e.g. leather trousers) or (b.) between leather and another material (e.g. leather shoes).

Technically, there are three different ways of joining leather to another material:

Stitching:
Similar to fabrics, leather can be sewn using special sewing machines that have enough strength to process this usually heavy and rather stiff material. From a functional point of view, stitching leather creates a strong and removable connection between both product pieces. With regards to sustainable development, this supports design approaches such as design for longevity, as it makes the product more robust, and design for reuse (chapter 4.1), as it allows for parts to be replaced and repaired without damaging the product or changing its appearance. On the other hand, this process usually needs to be done manually, which increases recycling or repairing costs. However, especially in the case of dress shoes, stitching requires specific material properties of the yarn used (e.g. high tensile strength). Therefore, usually polyamide or other plastics are preferred over cotton yarn.

Glueing:
A typical alternative to stitching is the less expensive glueing of leather. Apart from potentially hazardous chemicals in the glue itself, another disadvantage of this technique is its irreversibility. Usually glued parts can only be taken apart in a more or less destructive manner. Although this depends on the specific product, glue and position of the part, this eventually deteriorates the overall integrity of a product decreasing its potential lifespan.

Rivets:
A method that can have one of the strongest effects on the aesthetics of a product is riveting. For products such as some types of belts, tubular rivets are used to join two pieces of leather or create a loop that holds a buckle. From a recycling point of view, rivets are applied quickly and without the use of harmful chemicals (as opposed to glue) and can be removed mechanically, leaving only the hole where the rivet was placed.

Molding:
In the case of plastics, the bond with leather (or textiles for that matter) can also be done by directly molding the plastic around the leather part. While this is less common with leather products, typically the sole of low-budget sport shoes sometimes is directly molded around the textile parts. .

Other product-related joining methods:
Apart from these typical techniques to join a piece of leather to another piece of leather or another material, there are a number of other methods that relate to the product at hand. For instance, some pieces of furniture or bags use woven leather strips or a mix of woven leather and textiles. Obviously, this way of joining is less firm but is easy to disassemble.

Coatings and Finishes

The term "finishes" describes the top layer of leather. Their purpose is to prevent leather dyes from rubbing off on users, to protect the leather surface from environmental impacts (e.g. UV radiation, water, etc.) and to create a specific appearance (e.g. gloss, brighter colours, etc.).

There are a number of techniques and chemicals used for leather finishing which will be touch upon briefly in the following:

Burnishing describes a mechanical process throughout which grain leather or edges are continuously rubbed with a round object to create a smooth surface. Sometimes this is supported by the use of wax.

Polishing is a process that aims to make the surface glossy and shiny and is usually done by applying a liquid, creamy or solid substance. Polishing can be done several times even after longer periods of usage. With respect to sustainable development, many polishing products contain substances that can be harmful to humans and the environment.

Oiling leather surfaces serves the purpose of avoiding the leather to dry out or brittle. This is done with oils like castor oil, jojoba oil, shea-butter or other vegetable oils. In the DIY-communities, jojoba oil is particularly popular because it is less smelly and does not have a too darkened effect on the leather compared to other types of oils.

Comparable to oiling leather, solid or liquid waxes can be used as well.

Lacquering describes a process by which a thin layer of lacquer is applied to the surface. Depending on the desired functionality and aesthetic appearance of the leather, various different types of lacquer are available on the market. From a sustainable development point of view, these industry products may contain chemicals that are harmful for both humans and the environment. It is worth researching these chemicals and consider less harmful alternatives or even alternative functionalities and aesthetics if necessary.

Resins are another type of coating that is applied onto the surface of the leather. These materials, such as polyurethane, are produced to make the leather waterproof or resilient to other kinds of environmental impacts (e.g. UV-light). Resins are commonly used in many products such as car seats or handbags. One of the major disadvantages of this type of finishing is its usage of plastic that form a compound with the leather making it much more difficult to recycle, refurbish and generally uses non-renewable resources. However, on the other hand, leather that is finished with resins can be more robust and thus have an extended lifetime. With regards to sustainable development, it is recommended to perform a cost-benefit-analysis for this type of finishing.

There are a growing number of other finishing types, including color finishings and system solutions. The chemical industry is constantly innovating new technologies, substances and services that create new aesthetics and

functionalities. Design teams are advised to research both ancient and modern types of finishing and analyse them according to their desired design outcomes. In general, there is no ideal type of finishing with regards to sustainable development. Understanding the effects, weaknesses and potentials of the finishes at hand is an important step in the design process. The leather product design canvas (chapter 5.2) can help as a guide.

Conceptual Features

Product design comprises several different perspectives through which the process of product development can be seen. While technical features refer to the mere physical functionality of certain design elements and decisions (e.g. gluing vs. stitching), the term "conceptual features" or "conceptual design" describes the idea behind a certain product – it's concept. For instance, a typical leather product such as a wallet can be designed in a way that illustrates or even highlights signs of aging caused by scratches, UV radiation, mechanical friction and other external factors. The conceptual idea in this case would be to embrace the way leather can change over time creating uniqueness and emotional attachment as opposed to a design that aims to preserve aesthetical appearances through PU coatings, for example.

In this sense, the conceptual design of a product can be seen as a foundation upon which technical and aesthetic design decisions take place. After all, the concept of embracing the ageing process of leather does not define how this is done in terms of aesthetics (How and where is this process visible?) and technology (What is the right type of leather, tanning technique, finishing to foster the most appealing ageing style?).

Sometimes the conceptual design can be complex and comprise a number of aspects. The above-mentioned example of the ageing wallet could be linked to an general "natural" image of leather conveyed through both product and marketing campagnes. To support this concept, traceability of the hides and transparency regarding chemicals used and working conditions can be further pieces of the mosaic of this concept.

The right story for the right system

The aforementioned example of the wallet may not be applicable to all products and contexts. A proper understanding of the target group, the systemic context of a product and the impact on sustainable development are essential to design and develop an appropriate concept. In this way, it can be seen as a storyline that communicates a specific mindset.

This approach is closely linked to the business model (chapter 4.4) associated with this product. If a new leather product is meant to be part of a use-based product-service-system, a focus could be on a design-for-reuse approach (chapter 4.1). A possible conceptual design could therefore emphasize the notion "as good as new". In this case, making the aging of the material more visible could be adverse. Instead, designing the product in such a way that it

can be easy refurbished could be key to success. This could include techniques that allow parts to be easily disassembled (e.g. using stitching) and finishes that can be refreshed (e.g. pollishes).

All in all, conceptual design describes a part of the design process that goes beyond the mere product and relates to the overall ecosystem (see chapter 3.9) of the product. It can be a powerful tool to convincingly communicate and apply key issues of sustainable development that are mentioned in this handbook (e.g. design for longevity, traceability, use of more sustainable leather chemicals, etc.).

Formal-aesthetic Features

Formal aesthetic features are aesthetic design elements such as colour, shape, proportion, weight, etc. They are related to technical and conceptual features. The formal-aesthetic quality of a leather product refers to all aspects of this product that can be experienced with one's physical senses. This includes for instance the look of a product, its haptics, smell, weight or its subjective temperature when touching the surface. Obviously, this is closely linked to technical features as they mainly influence the specific aesthetic characteristics of a product.

There is a wide aesthetic variety when it comes to leather as a material. Depending on the type of hide being used (e.g. cow vs. deer), the tanning agents being applied (e.g. chrom vs. vegetable) as well as chemicals used for finishing and coating, such as PU.

This aesthetic variety is directly linked to issues regarding sustainable development. For instance, achieving certain aesthetic features (e.g. neon colours) may require the use of specific chemical additives. Furthermore, some types of leather are better used in one application than another. For instance, leather made from cow, deer or kangaroo hides usually have a higher tensile strength due to the specific structure of the animal skins, which makes them particularly suitable for footwear such as sports or casual shoes. Instead, using this leather for lightweight womens jackets may require additional chemical and mechanical treatment due to its heavy weight and stiffer haptics.

Aesthetics as a conveyor for value and associations

Even though consumers appreciate robust quality and repairability, most leather products are purchased for their aesthetic appearance. This is closely linked to the conceptual design behind the product. Rough outdoor leather bags usually require surface structures and an overall appearance that tends to benefit from small scratches and signs of ageing.

Understanding the versatility and aesthetic potential of leather enables design teams to better adapt their concepts to the target group and use cases at

hand. With regards to design for longevity, aesthetic features can convey the specific value of leather and support emotional durability.

Design teams should therefore perform a rigorous research phase before finalising the material selection of a leather product (see chapter 4.3). Understanding aesthetic features of specific types of leather, tanning agents, finishes etc. can be key to deciding on materials fit for purpose. There are numerous examples in the market that demonstrate that choosing the "wrong" type of leather for a particular purpose makes it much more difficult to maintain the product, extend its lifespan and create emotional attachment to it. Aesthetics can thus be a key driver to move from fast fashion to slow fashion or other forms of sustainable consumption patterns.

All in all, design is usually a complex iterative process that comprises various different phases and aspects. With regard to leather products, a significant level of material knowledge is recommended to create sustainable products. The above-mentioned categories can serve design teams to cluster their work packages and structure their processes. It is generally advised to form interdisciplinary teams including leather experts when aiming for more sustainable leather products. If this is not feasible due to limited budgets or time resources, empirical research methods such as structured interviews can be an alternative approach.

Business Model Features

This category refers to concepts and elements that focus on the creation of economic value added (leasing, product-service-systems, etc.). Particularly with regard to sustainable development, innovative and even disruptive business models pose high potential. They offer ways to extend the products' life, support circular economy and improve the user experience with the product. For a more in-depth analysis of this topic see chapter 4.4.

Material Selection (Leather & Supportive Material)

The design of a leather product involves to a large part all choices and strategies that relate to materials such as types of leather (including tanning and finishing) or supportive materials such as yarns, shoe soles etc. Each of these selections can have a profound impact on to what extent the final product will be more or less sustainable. This concerns not only issues such as the toxicity of the chemicals used, but also the products durability, reparability and recyclability (see also chapters 4.1 and 4.2). With respect to sustainable development, special attention should be paid to a materials traceability, which in turn affects a number of other aspects of the product and service design (see also chapter 3.5). For more information on material selection see chapter 4.3).

Marketing / Communication / Sales Concepts

This category summarises all approaches and aspects that aim to communicate features of the product or system regarding sustainable development (e.g. product information at PoS). Considering the long and broad history of this material (see chapter 3.7) and the potentially relevant information needed regarding traceability, toxicity and recyclability of a leather product, communication can be of high importance in the context of sustainable development.

As leather is a highly complex material, more sustainable leather products require proper marketing efforts and communication campaignes to succeed over less sustainable options in this competitive market. In this context, sales concepts are directly linked to business models. For more information on this topic see chapter 4.4.

Design Strategies for Sustainable Development (horizontal axis)

When designing for sustainable development in the context of leather products, four key strategies can be identified:

Design for Longevity

One of the most basic concepts is to extend the product's lifetime, thereby reducing the overall depletion of resources and energy. Extending a product's lifetime also reduces the total number of products used and the burden of product disposal. Design for longevity aims to develop products that can be used for a long time due to aspects such as durability, repairability or versatility. It is directly linked to the concept of reuse and related business models. For more information see chapter 4.1.

Design for Recyclability

Design for recyclability focuses on product and system properties that enable and support second (and third) hand use, or focuses on developing products and systems that facilitate material recycling. For instance, one way to support this is by making it easier to disassemble a product or by making sure that the materials used do not contain harmful substances. More information on this topic can be found in chapter 4.2.

Design for Process Optimisation

Producing leather and leather products involve many different steps, sometimes across continents, in a complex and often non-transparent supply

chain. Throughout this process waste is produced (e.g. waste water while tanning or cutting waste), energy is consumed and emissions occur (e.g. CO2). Focusing on aspects that improve processes such as production, logistics and packaging (e.g. by avoiding waste) can have a significant impact on the products overall performance with regards to sustainable development.

Optimising processes summarises a huge amount of topics that cannot be covered in this handbook. It relates to improved tanning processes that require less chemicals or water. It can affect logistics by centralising key production steps in one location. And it refers to simple measures such as reduced packaging formats with recyclable materials. Design teams are therefore advised to gain a proper understanding of the system at hand including the product's ecosystem (see chapter 3.9) and its supply chain (see chapter 3.2).

Design for Risk Management (Health / Environment)

The fourth pillar of design strategies is perhaps the most relevant and at the same time most complex topic in the field of leather products. Design for risk management refers to features of the product or system that increase safety for humans and the environment throughout the product life (e.g. traceability of chemicals). Because the global leather supply chains are complex and often non-transparent, managing risks with regards to health and the environment does not end with the selection of a specific material based on a label, but with understanding and actively managing the interrelated aspects of the product and its entire ecosystem.

The biggest effects in this context could come from focusing on chemicals used throughout the entire production phase. These chemicals can harm the environment and the production workers, or could still be found in the final product posing danger to the consumer or the environment once it is disposed of. For more information on this topic see chapter 3.3). Traceability and information management is the best way to manage the risks derived from improper usage of chemicals (see chapter 3.5).

2.4
Aspects of „More Sustainable Leather“

Egbert Dikkers, Andreas Meyer

As these guidelines refer to more sustainable leather products, an understanding of the relationship between leather as a material and sustainable development is essential. With regards to the United Nations' Agenda 2030, sustainability is rather a journey than an ultimate goal. We therefore refer to the terms "sustainable development" and the comparative modus of the adjective "more sustainable" to indicate this process. It aims at triggering the debate for improvements that can be used by design teams as a basis for their decision making.

As complex as the topic sustainable development so is the term "sustainable leather". While there is no official definition to be referred to and design teams as well as consumers might relate different aspects to it, one can agree that no single product is 100% sustainable[1]. In globalised economies and increasing complexities of supply chains as well as products and their ecosystems, improvements on one site can lead to sever unwanted effects on another part of a system. Therefore, a systemic understanding of leather and sustainable development is needed. For the purpose of these guidelines, it is worth summarising key aspects to be considered for what might be called "more sustainable leather".

[1] For a deeper understanding of the notion of sustainable development see chapter 1

Leather is a material that has the opportunity to take an important role in a circular economy as also described in chapter 3.1. Due to its natural origin, high durability and versatility, it can be an important factor in creating more sustainable products, if used appropriately. It is produced globally as indicated in chapter 3.0 and is increasingly controlled through certification processes that focus on environmental aspects to ensure that leather is manufactured with a minimum environmental footprint.

However, in certain parts opaque supply chains and the focus on low product prices are the basis for processes that may have negative effects on human health and the environment. The same applies to the safety and social circumstances for people involved in the manufacturing of leather. Still, a part of the global leather manufacturing, as a lot of other manufacturings as well, is done under circumstances where people are exploited and exposed to harmful substances. As an attempt to counteract these tendencies, increasingly national and international legislation as well as value chain

due diligence is enforced. Furthermore, social standards are included in measuring the performance of a value chain and the final product that ends up at the consumer. More concrete, current leather manufacturer certification programs increasingly include recognition of social standards to acknowledge the importance of taking responsibility for total sustainability.

Going more specifically into 'more sustainable leather', many members of the leather value chains are working towards transparent and cooperative supply chains where stakeholders can cooperate and work together to achieve the principles and objectives of a more sustainable leather.

Examples of this include Leather Working Group, ICEC, CSCB, Oekotex, Bluesign, ZDHC, IVN, Blue Angel to name the most influential ones. The Sustainable Leather Foundation developed an entrance in this as well while the United Nations Economic Commission for Europe (UNECE) is working on a global project to „enhance traceability and transparency for more sustainable value chains in the garment and footwear sector".

Next to these programs, brands often do social audits including examples like BSCI, SLCP, SMETA, WRAP, FSLM, SA8000 or have this topic covered in brand specific programs, depending on the risk and their brand focus.

These processes indicate an increasing awareness regarding sustainable development in the leather sector. However, despite the efforts of frontrunners and some industry leaders, on a global scale there is still a wide range of leather manufacturing practises and a significant gap between proactive companies aiming for sustainable leather chemistry and decent working conditions and the ones that ignore long-term threats to both humans and the environment. Due to the complexity of the transcontinental supply chains and the use of potentially harmful substances, design teams that aim for more sustainable leather products need to understand the systemic dimension of leather as a material. From a product development point of view, it is therefore important to know key parameters and indicators to estimate to some extent whether a leather is more or less sustainable. To get a clearer picture of these differences, knowing what to consider and look out for is essential when aiming for more sustainable leather products.

The United Nations have introduced the concept of Sustainable Development Goals (SDG's) as a framework for global improvements on issues including poverty, the environment and social circumstances in the manufacturing and consumption of products and services. Many stakeholders throughout the leather value chains are increasingly embracing this concept, confirming that leather manufacturing is not only about environmental topics, but also about safety and social circumstances to name but a few. For a comprehensive illustration of the relationship between the leather supply chains and the SDGs see also chapter 1.1. In order to get a first idea of what might be called "more sustainable leather" three topics can be used as a starting point:

- **People:** people working in the leather industry should be able to work inclusively and safely, have a decent income and sustainable economic growth. Transparent supply chains, trustful communication and IT tools for traceability can help improve the working conditions.
- **Animals:** the hides and skins originate from the food industry which is increasingly taking responsibility to ensure that animals are kept under decent circumstances with respect for the five freedoms. It should be realized that animals that have been fed rightly and had sufficient movement will have a better hide structure. On the other hand, natural scratches or the impact of insects on the hide and skins are more likely to happen with animals that lived outside, compared to animals that lived inside. In this regard, design approaches can actively embrace natural scratches or insect bites as signs of uniqueness. From a systemic perspective, industry and brands are recommended to support an image of leather as are natural material as opposed to synthetic-like homogeneous surfaces.
- **Environment:** The production of hides and skins should not be involved in illegal deforestation, which still takes place in some regions. Leather should be manufactured according to best practises limiting unnecessary transportation of raw hides and skins, limiting the use of water and energy, using chemicals in a way that they are not hazardous for the environment and thorough waste (solid/liquid) management. Again, transparent supply chains and traceability structures can support this development and foster sustainable business models that help industry transform towards sustainable development.

From a more technical perspective, tanning itself is a mainly chemical process. Only with the help of chemical agents does the skin/hide become durable. Human skin is very similar to animal skin, which means that the chemicals used in a tannery basically also affect humans and other organisms. Needless to say chemical management is key to make use of tanning technology to create durable materials while protecting humans and the environment. Although chemical process innovations and other developments aim at improving efficiency and safety of tanning processes and reduction of environmental burdens, tanning by default requires effective chemicals that are potentially harmful if not used adequately. While some tanning agents and chemical processes might be superior in contrast to others with regards to sustainable development, proper education and safety standards, traceability of chemicals throughout the supply chains and external audits are essential pillars of a more sustainable leather chemistry.

As a result, a material that is referred to as "more sustainable leather" might embrace developments such as:

- Sourcing hides and skins from regenerative farming practises
- Sourcing hides and skins from countries where animal welfare is respected
- Less transportation of raw hides & skins

- Preferring the use of fresh hides instead of salted hides
- Manufacturing with reduced water use or without water
- Replacing fossil based chemistry with biobased chemistry
- Taking steps into better biodegradability
- Reducing waste and using waste streams within the process
- Sourced from companies that use resource efficient chemicals.
- Sourced from companies that have a chemicals management system in place that identifies chemical hazards and aims to reduce exposure and risks in terms of toxicology and ecotoxicology.[2]
- Reducing the use of synthetic additives and coatings means, to use leather where it is usable, respecting the properties of leather
- Stimulating caring practise by celebrating natural characteristics of leather
- Re-using leather from consumer articles in for example leather fibre articles
- Energy management towards energy efficiency
    - Reducing greenhouse gas emissions along the entire supply chain
    - Using energy from renewable sources
- Using scientific data (Life Cycle Assessment) to stimulate progress.
- Traceability of chemicals throughout the supply chains (see chapter 3.5)
- Business models and manufacturing structures transparent and respectful, clear for consequences
- Long-term business collaborations that foster trust and enable transparency along the supply chain
- Safe and fair working conditions in the various production stapes along the supply chains

For a more comprehensive discourse on issues of sustainable development with regards to for instance supply chains, chemicals, consumption patterns, traceability and information management, policy impulses and other aspects see the respective subchapters in chapter 3.

While this list does not claim for completeness, it can be seen as a starting point on the way to define more sustainable leather and support industry initiatives that aim at implementing these developments.

With regards to the design of leather products, design teams are recommended to conduct proper research regarding their sourcing processes. The above

[2] see also literature regarding „Green Chemistry" und „Benign by Design":

Lorenz et al. (2021):Toward Application and Implementation of in Silico Tools and Workflows within Benign by Design Approaches.

Anastas and Warner (2000) Green Chemistry. Theory and Practice.

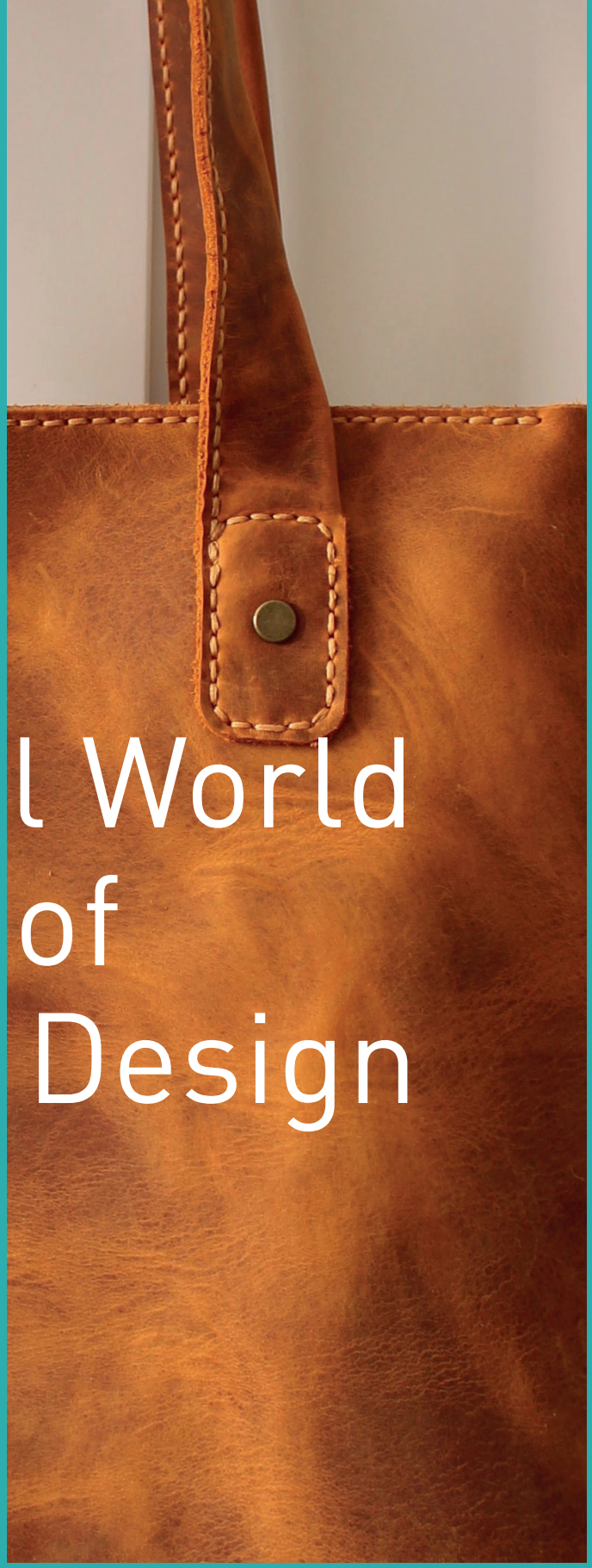
Anastas, Paul (1994): Benign by Design Chemistry (https://pubs.acs.org/doi/pdf/10.1021/bk-1994-0577.ch001)

mentioned criteria can be helpful guidelines to audit potential suppliers. While this research effort might cost time and money at first, it can create benefits in the long run. Long-term collaborations between brands and leather producers as well as structures for increased transparency and traceability can be strong drivers that ameliorate initial costs.

Furthermore, whether a specific leather is more or less sustainable also depends on the use case. While some products require more durable leather, more intensive processes might be justifiable. On the other hand, even the most sustainable leather might not be appropriate to products that do not make use of the specific properties of this material.

3

The Real World Context of Leather Design



Compared to most other materials that are used in everyday consumer products, leather can be described as an extraordinarily complex, versatile and controversial material. It is related to ancient history, a number of cultural practices, connotations and by default is associated with globalised production and consumption patterns. In terms of sustainable development, on the one hand, leather has several features and characteristics that makes it a superior material in contrast to many, for instance, synthetic alternatives. On the other hand, the global leather supply chains are also linked to processes that are harmful to the environment and humans if not carried out under the right circumstances. This applies in particular to leather chemistry and its impact on environmental, social and technical dimensions of the supply chains and the final leather product.

Aiming for more sustainable leather products, designers and other professions involved in the development process are required to know key aspects related to leather as a material, as well as its context and its relation to sustainable development from a systems point of view. The following chapter provides an interdisciplinary and multi-perspective overview of this field as a basis for design strategies and decisions. At the same time, it does not claim to cover all relevant topics and aspects that should be addressed in the context of leather product design and sustainable development. Continuous technological, legal and scientific developments and innovations require curiosity and ongoing research for design teams to foster the best and most sustainable outcomes of their endeavors.

3.1
Characteristics, Potentials and Limitations of Leather as a Material

Egbert Dikkers

Characteristics

The vast majority of leather is made from the hides and skins of animals raised primarily for the production of food[1]. These hides and skins would otherwise mostly end up in landfill. It should be recognised that there is no financial incentive (1) for a farmer to raise animals (cows, sheep, goat, pigs) for their skins. As such, the availability of leather is limited by the consumption of dairy and meat. Currently, upcycling the hides and skins to a long lasting material with unique characteristics is the best option. A small amount of the leather industry (approximately 1%) consists of skins from reptiles. This guideline does not focus on reptiles, however, to learn more about reptile leather please study the FAQ (3) about exotic leather that was set up by EPIC.

[1] There is a debate if the hide and skins are a by-product or a co-product.

Leather is made from the hides and skins from different animals with all of them having their own characteristics.

- **Cow leather:** represents approximately 69% and is mostly used in car seats, upholstery, bags, shoes, leather goods due to its size, thickness and strength.
- **Sheep leather:** represents approximately 13% and is mostly used in garments, gloves and linings due to its softness, its fine grain and the ability to create thin pieces of leather.
- **Goat leather:** represents approximately 11% and is mostly used in lady shoes, bags and linings due to its grain and the ability to create thin leather and suede.
- **Pig leather:** represents approximately 6% and is mostly used in shoes and linings.
- **Kangaroo leather:** represents less than 1% and is mostly used in shoes and belts.
- **Reptile leather:** represents approximately 1% and is mostly used in accessories.

Depending on the origin of the hides and skins, the applied tanning process and how the following processes have been organised, the leather will show different characteristics in relation to breathability, softness, stretch, tear strength, UV resistance, soil resistance, and as well in relation to biodegradability at the end of its life.[2]

[2] To learn more about leather manufacturing, consider consulting https://www.leathernaturally.org/Education/Fact-Sheets or https://leatherpanel.org/

5.000 years ago Egyptians started making and using leather, as described in Chapter 3.7. Since then, the leather industry has developed and created unique characteristics to this 3D structured material. The properties of leather include the below:

- **Waste reducing:** Leather adds value to a circular society that wants to consume less, reuse more and recycle by-products and end products.
- **Durable:** Well made leather lasts a long time and unlike most man-made, or synthetic materials it can get better with age, acquiring a depth of patina and wear pattern that is individual to the user.
- **Repairable:** Materials made with leather can be repaired, increasing employability through people working in repair services. Unlike many alternative materials it can be easily maintained (mostly cleaned with a damp cloth) without much or any laundering and potential releasing of synthetic microfibres/microplastics ending up in the waste water.
- **Recyclable:** Leather can be recycled by repurposing, e.g. leather furniture from airplanes after their commercial lifespan (sometimes 10-12 years) can be recycled into leather goods. At the very end of its life leather has the potential to biodegrade in a timespan of 10 to 50 years, depending on type and finishes. In contrast, synthetic materials can take thousands of years to decompose.
- **Versatile:** Leather has many varied end uses. Leather can be engineered to be durable enough for furniture yet soft enough for comfort footwear. It will make the finest dress, gloves or protective, abrasion-resistant motorcycling gloves. Leather makes the most supple of jackets or the firmest of walking boots.
- **Comfortable:** Leather has a natural comfort. Leather has a 'breathability' that more easily allows the body temperature to be regulated. It will naturally absorb and hold moisture away from the skin until it can evaporate to the outside. Also, leather adds further comfort to the wearer through its ability to be supple.

Potentials

Leather has a huge potential in a circular society that wants to reduce waste, reuse more and recycle end products. The potentials are:

- **100% utilization of hides and skins:** it should be ensured that 100% of these materials are upcycled into leather (and other products) instead of

being wasted or downcycled.

- **100% use of waste streams** generated during the process of consumer products (i.e. use of shavings, trimmings, etc).
- **Biodegradability:** leather is biodegradable, although this depends on the manufacturing process and the type of finish.
- **Employability:** the leather industry employs millions of people and manufacturing a leather article takes artisan skills. Repairability can add further employability through repair service centers.
- **Natural fibre:** leather is a natural fibre that does not need any dry cleaning or laundering and thus does not release microfibres/microplastics into the environment.
- **Circularity:** at the end of the life cycle, when the leather can no longer provide a useful service through repair or recycling, it is possible to dismantle products and incinerate the leather into a biofuel that can then be used to manufacture the next generation of leather.
- **Personal identity:** leather tells a story and with a natural finish, every piece of leather is unique.
- **Education:** brands, designers, influencers and consumers increasingly do not realize the positive impact the use of leather has on a circular society. Key educational topics include: No animals are being killed for the use of leather, the leather industry is largely regulated, vegan materials are largely made from synthetic materials and pictures of a tanneries found on the internet are outdated and do not reflect the reality of today's leather industry.

Limitations of Leather as a Material

The limitations include:

- **Availability:** the availability of leather is limited to the number of animals slaughtered.
- **Price stability:** the prices of hides and skins can strongly fluctuate over time.
- **Cutting losses:** originating from a hide or skin, the material does not have a squared size that can be provided on uniform rolls like alternative materials. This often results in cutting losses that are automatically being downgraded.
- **Weight:** leather tends to weigh more compared to various synthetic materials.
- **Price:** leather tends to be more expensive than alternative materials.

However, it is likely that the total cost of ownership of a leather material is more favourable over its lifetime.

- **Wetness/Moisture:** synthetic materials tend to dry better and quicker than leather.
- **Natural material:** animal leather is as robust as human skin, but it is not indestructible. Water, sun and physical use under normal conditions are preferred for leather. When leather is used under "extreme" conditions, more care is required in cleaning and maintenance. When leather is used under "extreme" conditions in combination with a minimum of care, special surface treatments, finishings and applications are required. However, this will result in a loss of properties. Furthermore, leather can come with natural scratches, insect damage and other imperfections.
- **Environmental and social risks:** during the production of leather, certain chemicals and processes come in use that can create an unbearable risk, if not controlled and well managed. Modern tanneries have strict legislation and regulation in place to protect against risks such as allergic reactions, air, ground and water pollution.
- **End of Life:** the more the hides and skins are processed for durability and performance, the less the natural biodegradability properties are retained.

References

(1) US Leather (2022): https://www.usleather.org/press/Using_leather_does_not_mean_more_cattle_are_reared_finds_research#main-content, last checked, 18.03.2022.

(2) Epic Biodiversity (2022): https://www.epicbiodiversity.com/faqs, last checked, 18.03.2022.

3.2
Global Leather Supply Chains

Andreas Meyer, Karen Lehmann, Jonas Rehn-Groenendijk

Many steps are involved to turn a hide into a leather product. The supply chains nowadays are often complex, global and intransparent. As illustrated in the schemata below, the hide changes hands frequently in the production process, adding to the complexity. To understand these complexities, it is first important to gain a general understanding of the different stages of the leather supply chain (see fig. 3.2.1).

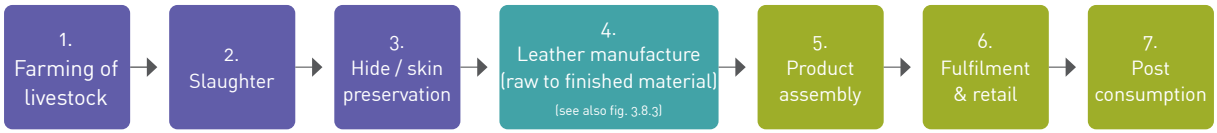


Fig. 3.2.1)
Simplified illustration of a leather supply chain
(based on UNECE Enhancing Traceability and Transparency of Sustainable Value Chains in the Garment and Footwear Sector: Business Process Analysis for Sustainability and Circularity in the Leather Value Chain)

From Cow to Hide

Global distribution of cattle and hide production

According to the Food and Agriculture Organization of the United Nations (FAO, 2016) an average 41.1 % (682.400 head) of the global herd of 1.659.600 bovine animals (including buffaloes) were located in Asia between 2012 and 2014. The second biggest share can be found in Latin America with 24,3 % (403.800 head) and the third biggest share in Africa (17,6%; 291.700 head). In the year 2015, 220.566 bovine animals were bred in Brazil alone, which is the second biggest herd after India with 334.318 animals. Becoming an important industry in Africa, numbers of bovine animals are constantly rising in Ethiopia to 56.310 animals in 2015.

On average, between 2012 and 2014, 6.531.000 tonnes of hides and skins were produced worldwide. 29,9 % of them came from Asia, another 26,9 % from Latin America and 14,8 % from Europe (FAO, 2016: IX).

These numbers illustrate the distributed and specialised global leather supply chains. While the biggest tanning industries can be found in Asia, most of the raw hides are derived from Brazil. Already the first tiers of the global

leather supply chains require enormous logistics to transport raw hides from countries such as Brazil, Ethiopia or Argentina for the tanning process to countries such as Bangladesh, India or China before moving on to other parts of the world for finishing and shoe production.

Various factors along the supply chain determine the quality of leather

Different characteristics of a hide determine its best use case. In southern Germany, Austria and Switzerland, cattle were initially bred for dual use (meat and milk production) and usually slaughtered at a comparatively old age. Through more extended growth periods, the resulting hide becomes thicker and larger, which predestines it for use in furniture and automotive production. In modern times, cattle are no longer in dual use, although the breed retains some of these characteristics. Next to cattle, goat or sheep leather is also prevalent in apparel, shoes and accessories. Nowadays though, skins from sheep and goat are losing their appeal because skins (small hides) require more work (cost) per piece than hides (bigger hides).

The production of shoes and apparel requires different characteristics in leather. There, the hide can be smaller and thinner. Due to the nature of the products, the hides are cut into many smaller pieces.

Regardless of the end use, the cattle's health is crucial for the quality of the hide. The better skin structure, resulting from more animal-friendly rearing with less focus on massive growth and more on physical activity, usually translates into higher quality leather. Natural causes like small scratches from shrubs or fencing can damage the skin. As cattle on more sustainable farms tend to live longer, their potential to incur these kind of scars increases. However, these natural damages associated with an animal friendly rearing are not appreciated by the consumer, which is why these "faults" are covered up in the leather production process (e.g. with PU coating).The conventional rearing of cattle can cause a lot of damage to the skin too, e.g. mast pleats due to rapid growth or skin disease due to prolonged unhygienic housing conditions. These kinds of damages could be prevented and the relevant industries should address these in the coming years.

The health of the hide is not a priority in abattoirs, which do not necessarily take into account the needs of the leather production industry in their actions. Thus, there can be additional damage to the animals (and consequently to the hide or skin) associated with the handling and transporting of the cattle. Next to being abhorrent for animal welfare, these damages will make a skin unusable for leather production. Because hair covers these damages during the first steps of the production process, they will often only become apparent after the liming / tanning process. Therefore, ensuring quality treatment at the beginning of the supply chain is of utmost importance. Furthermore, the

method of separating the hide via a mechanical process is preferable to a manual removal with a knife from the leather production point of view, as it causes less damage to the raw hide.

After slaughter, the hides changes hands to a hide trader who sorts the hides by breed, weight and quality. The hides and skins are cooled or treated with salt and sometimes chemicals. From there, the hides enter the tanning process, where they may be transported to several different stations. At times, mold protection is used during transport. And at every station, there may be chemicals in use. All chemical suppliers should follow REACH regulations and CLP (classification, labeling, and packing of chemicals and mixtures). All buyers of chemicals in this supply chain should agree on this as well.

Fig. 3.2.2) Tanning drums (photo: Südleder & Ecopell)

The high standard of regulation of chemicals regarding worker and environmental safety in Europe is a significant achievement. But in a global world, if not carefully installed and/or controlled, this can lead to some unintended consequences, for example with regards to production relocation. Some fear that the recent treatment of glutaraldehyde (GLA) by the European Chemicals Agency (ECHA) could lead to such circumstances. Nowadays, European tanners use glutaraldehyde for chrome-free tanning and its use is safe for workers in Europe. After tanning, the leather structure binds the GLA completely, making it undetectable. GLA can be harmful to human health, especially when inhaled. It has been submitted as a candidate to be included in the list of substances of very high concern (SVHC) by ECHA. Some fear that the production of chrome-free leather will now relocate to countries with less oversight and regulation, where GLA will be handled in a less careful manner, thus endangering the worker's health in these countries.

Global leather supply chains differ by product category and actual product. Since roughly half of the global leather production is used for leather shoes, a typical global supply chain for shoe production is used as an example of the different supply chains for the purpose of illustration.

From Hides to Wets

The use of leather as a material requires a relatively large amount of skilled manual labour in production. A shoe made of woven materials can be produced mainly by a machine; the remaining manual assembly can be completed by unskilled labour. The production of a leather shoe cannot be automated to that degree and requires a more extensive skill set.

The actual process of making leather out of hides is a complex one that includes many different steps with a number of chemicals and mechanical processes (see fig. 3.2.3). Before the tanning process can take place, hides are soaked, the skin is disintegrated in the limer to remove hair and loosen the skin fibre structure. After the mechanical removal of the subcutaneous connective tissue (unfleshing) and sometimes splitting (if the skin is too thick), deliming and enzymatic pickling take place. For skin types with a lot of natural fat (such as pig or sheep), additional degreasing and, for some tanning types, additional pickling is done.

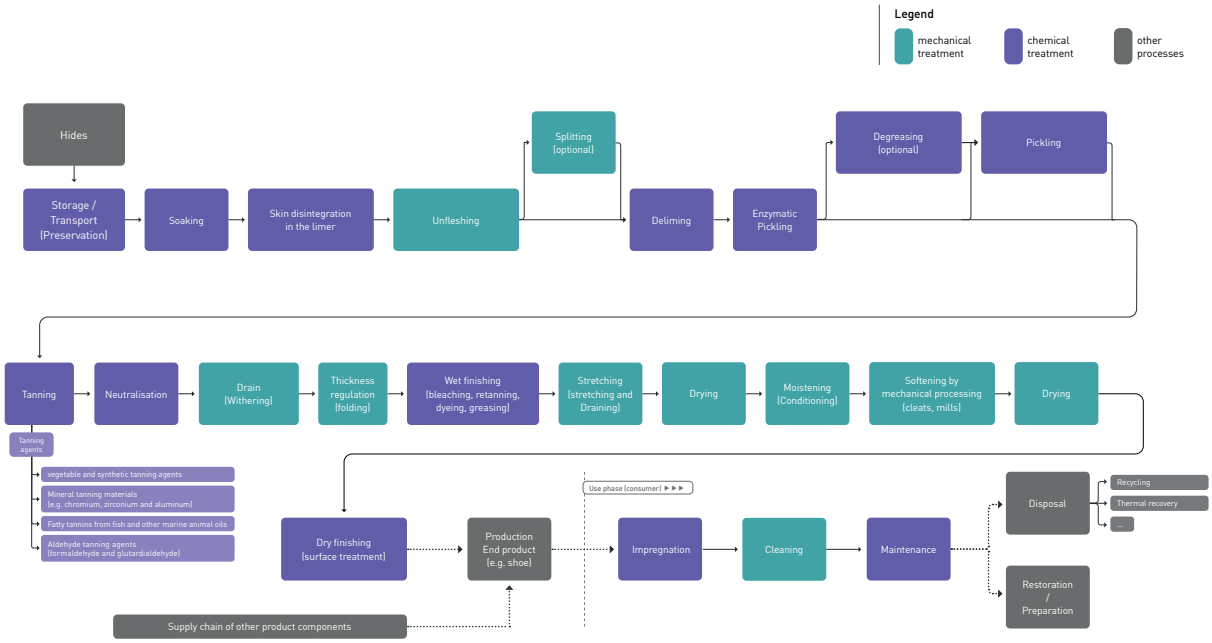


Fig. 3.2.3) Simplified illustration of tanning process (for a larger version of the illustration see p. 216-217)

After this first phase, the hides are ready for the actual tanning process, which can be done with the use of various tanning agents (e.g. chromium, glutardialdehydes, fatty tannins from fish, vegetable tanning agents or

other newly developed tanning agents). Once this tanning phase is finished, neutralisation, drain (withering) and thickness regulation are carried out. Depending on the tanning agent used, the result is what is called in the industry wet blue (from chromium tanned leather), veg tan green or wet white.

Fig. 3.2.4) Hides after vegetable tanning process (photo: Nina Conrad, bttr GmbH)

Since these wets are commodities, usually at this point the raw material changes ownership sometimes across countries or continents.

From Wets to Leather

From there on, the wets undergo wet finishing, including bleaching, retanning, dyeing and greasing. Here, sometimes colorants are used to change the colour of the future leather according to the desired design.

After this, stretching, draining, drying and moistening (conditioning) takes place before the material is softened by mechanical processing (cleats and mills) and dried. Finally, during dry finishing, the surface is being treated by, for instance, burnishing, polishing, oiling, lacquering or the application of a coating layer from polyurethane (see also chapter 2.3).

This last step of dry finishing is sometimes performed by specialised companies. The finished leather is then usually sold via global leather dealers.

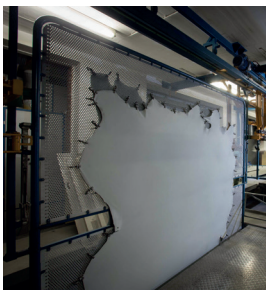


Fig. 3.2.5)
Streching and drying of wet blue
(photo: Südleder & Ecopell)

From Leather to Shoe

According to APICCAPS (Statista 2022) 3,2% of the global shoe production is allocated in Europe . With regards to leather shoes in particular, according to FAO (2016) 4.565 mio pairs of leather shoes had been produced globally in 2014. While most of these shoes were produced in Asia (2.759 mio pairs), 17,7 % of the global share (807 mio pairs) were produced in Europe. The most important european region in this regard is from Italy (302 mio pairs) followed by Spain

(74,8 mio pairs). These production regions primarily specialise in high-quality products, which are often associated with high prices. This association is mainly due to the higher and stricter standards in the production process. In general, these production locations only comprise a small part of the global shoe market.

The primary source of shoes for the global market is China (54,6% of the global share in 2021), followed by other Asian countries. In particular, India, Pakistan, and Bangladesh have large shoe industries. Once production costs rise in a country, e.g. due to stricter environmental protection laws, recent history shows that manufacturing is likely to move to another country, where production can resume at lower costs.

The „made in Europe“ distinction is, at times, also used as a marketing ploy. The definition of the place of origin is sometimes difficult to determine and poses tricky questions. For example, should a shoe be marketed as "made in Europe" when the shaft production takes place elsewhere and only the assembly of shaft and sole takes place in Europe?

For the designer, it can be hard to track these conditions along the supply chain. A procurement from suppliers within Europe can thus have several advantages: Standards for worker's safety and compensation are comparatively high, often due to stricter laws and regulations. In other producing countries, such as India and Brazil, production costs may be lower, however this often correlates with lower standards.

In addition, regional procurement leads to shorter distances, resulting in lower transport-related emissions. Furthermore, the processing of the hides without salt, as commonly done in European countries, reduces the necessity of complex salt-extraction processes of the wastewater.

What can Brands Do?

Companies can set requirements on these issues in their procurement guidelines.

It requires honesty and a willingness from brands to ask uncomfortable questions. If the business address of the supply company, e.g. is a skyscraper in Hongkong, it is unlikely that this is the actual location of production. It is within the means of a brand to ensure it has all the necessary information to comply with its own guidelines and this must be accompanied by transparency. If a brand makes certain commitments publicly, it should also have verifiable proof of these statements.

Some companies offer products marketed as "sustainable" at competitive, low prices. Given the costs of "bio-grade" materials, marketing and transportation,

it becomes clear that issues such as worker compensation and safety are not sufficiently addressed in these products. The consumer, however, has not yet developed much awareness of such issues.

The supply chain law, which was passed in Germany in 2021, can provide an impulse to companies to further investigate their supply chains and put necessary control in place. The move towards more transparency in the supply chain is welcome. There are already some model companies, such as Meindl, who can trace their supply chain completely, but that is still the exception. Especially in case of large scale operations and globe-spanning supply chains, ensuring traceability can seem complicated. Many companies also fear competitive disadvantages from disclosing certain information, e.g. with regards to their supplier. However, there are possibilities of ensuring expedient information exchange and traceability along supply chains while maintaining trade secrecy. This topic is further explored in Chapter 3.5: Traceability and Information Management.

The regulatory landscape is currently changing with regard to chemicals management along the global supply chain. Next to the supply chain law in Germany, especially efforts on the European level are noteworthy. With the EU Green Deal, the European Commission lays out an ambitious reform plan that will have an incisive influence on many industry sectors. Chapter 3.9 explores the policy impulses radiating from the EU Green Deal.

Some companies require a certain carbon footprint for their products. Such a requirement should be well considered, as it only covers some aspects of a product's environmental impact. Leather has a relatively high footprint, as the rearing of cattle is (to a percentage) included in the overall footprint. However, with good care, a leather product can last for decades. A product made from synthetics, such as used in modern sneakers, will probably have a much lower carbon footprint. This is especially pertinent if the synthetics are recycled. However, synthetics also have disadvantages: they are less degradable, are based on fossils and the woven sneakers are less reparable and long-lasting than comparable leather sneaker.

The Role of Design and the Designers

Taking all this into consideration, design teams aiming for more sustainable products need to be aware of the complexity and partly intransparency of supply chains and develop strategies that counteract this. Establishing close and trustful relationships with suppliers can be a starting point. This can even offer additional potential for business models, unique selling propositions and marketing campagnes. Economically, this can be further beneficial as these partnerships ensure sustained supply and can support quality management.

Furthermore, with regard to the selection of materials (see also chapter 4.3) and suppliers, it is not enough to focus on a specific type of leather or threshold values of chemicals to be detected in the material. Instead, a holistic view of supply chains is needed that considers environmental and social aspects based on traceability and transparency.

With this in mind, aspects of supply chains can be a specific part of the conceptual design and business model of a leather product. For instance, the complexity or even length of a supply chain can be reduced by using more regional suppliers or reducing the total number of suppliers by adapting sourcing strategies.

Similarly to examples from coffee or bananas, sourcing and traceability can be an inherent part of the conceptual design and marketing strategy, focusing on, e.g. the support of specific suppliers or supplying countries.

All in all, supply chains need to become part of the design briefing when aiming for more sustainable products. Only if ideation phases and concept development are based on an extended scope that reaches beyond material properties and consumer behaviour, products can become substantially more sustainable. Therefore, design teams need to understand the various interdependencies and challenges that derive from the supply chains' complexity. Based on this systemic point of view, more sustainable and partly even disruptive products, services and business models can be developed.

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APICCAPS @ Statista 2022: https://de.statista.com/statistik/daten/studie/1150498/umfrage/verteilung-der-schuhproduktion-nach-laendern-weltweit/, last checked 14.04.2022.

3.3
Leather Chemicals and Sustainable Development

Egbert Dikkers, Dirk Bunke, Frank Schael, Patrick Rojahn

Chemicals have a strong impact on the efficiency and environmental footprint of a leather manufacturer, the final appearance of leather, the longevity and consumer experience and the end-of-life status of the consumer product. In addition, it is important to realize that chemicals need to be handled safely at all times.

The leather value chain, including brands and leather manufacturers, is increasingly recognising the importance of the total cost of production, including the minimisation of waste, the handling of waste and the fact that better chemistry may have a higher price per kg, but a lower total cost price. This incentive is crucial for the leather value chain to create and implement innovations.

Challenges

The challenges include the below:

- The cost of waste handling is not recognised globally. There needs to be an understanding that the value chain is responsible for doing the right things in the right way.
- Lack of availability of scientific data, for example, to create an Lify Cycle Analysis (LCA) for a chemical or the finished leather.
- Optimisation of leather manufacturing processes so that leather and its waste streams can be composted.
- Misinterpretation of LCA data can lead to unfortunate decisions. For example, an innovation may have less favorable LCA data comparing product A to product B, but result in less usage of other chemicals in another part of the process that finally results in a better LCA outcome for the finished leather.
- Sustainable innovations may initially lead to a slightly higher cost price for leather.
- Required physical characteristics may initially be more difficult to reach, like for example resistance against soiling or sunlight.

- Inability to create a good and simple marketing story for the final leather article consumer.
- The proper (and environmentally sound) application of chemical substances in leather chemistry may require additional knowledge of the processing staff, which could be a problem in plants with a low technically trained workforce.
- Simple solutions to transition to more sustainable chemistry are not widely available. For example, when looking at the available approaches for the tanning step, where the hide is processed into the durable material leather, all common chemical agents have their advantages and disadvantages. The predominant chromium-based tanning can lead to contamination of the process and products by the toxic heavy metal chromium VI under conditions that are not easily to control. Synthetic fossil-based alternatives, such as glutaraldehyde, are a challenge for environment and occupational health due to their hazard classification. Vegetable tanning agents are associated with lower impacts on human health, but may be less efficient in terms of water and energy use compared to the more matured alternatives and may also cause environmental problems (land use).

Trends

- Bio-based chemistry is a current trend, with most chemical companies trying to replace fossil-based chemistry.
- Making LCA data available to the leather value chain becomes more important for innovations.
- Optimising chemicals, reducing hazardous substances, as well as optimised take up during the leather manufacturing process.
- Increased collaboration projects between chemical companies, leather manufacturers and brands to jointly look for sustainable developments.
- Increasing importance of supply chain collaborations like for example the ZDHC initiative.

For a Better World: Leather Design and Sustainable Chemistry

From liming the hides in the tannery to polishing a well-designed leather shoe: chemicals are essential partners in all stages of the life cycle of a leather product. Innovative design of leather products therefore includes the use of best-in-place chemicals. This does not only mean avoiding chemicals which can have negative effects on humans or the environment. It also addresses the broader view of sustainability, it asks for social responsibility

and the well-being of people and the planet. What are the key steps to realise sustainable chemistry in product design?

Leather and Chemicals

Leather chemistry is a central theme as old as the history of leather production. It started thousands of years ago with the use of naturally occurring ingredients from tree barks for the tanning of leather. It evolved into a fascinating, diverse world of leather chemicals with worldwide ten thousands of products, using more than a thousand single substances as raw materials for high-performance chemicals.

Numerous steps in leather production require reactive substances to do their job, e.g., cross-linking collagen molecules in the tannery. Such chemicals can not only react with the raw hides, but also with the skin of the workers who handles them. High levels of salt in process waters can damage animals and plants in rivers if wastewater from production sites is emitted without treatment techniques to reduce the chemical load.

Therefore, many steps in leather production require a sound management of chemicals. This starts with the careful selection of chemicals used, followed by appropriate measures to avoid exposures and emissions in the production process. This also includes the responsible treatment of solid wastes and wastewater. In addition, chemicals are also applied during the use of the final product, e.g. to care for the shoes. Innovative leather design also means taking measures to ensure that the right chemistry is used in the right way throughout the life cycle of the product.

Fig. 3.3.1) Chemical processes are complex and require extensive knowledge. Here, build-up of rectification process (Photo: Gregor Schuster, 2020)

Depending on the definition, up to 20 individual manufacturing steps are usually necessary to convert raw hides and skins into leather. A detailed discussion of all steps is beyond the scope of this work, but can be found in the literature (1). This section will provide a brief introduction to leather manufacturing and the chemicals involved.

Among the manufacturing steps, tanning is the central and currently probably most discussed fabrication step for leather manufacturing (1) (2). Tanning is the step in which putrescible organic material is converted to a stable material that is not degradable by spoilage bacteria. The chemical principle of tanning is basically crosslinking the collagen groups of skins, which can generally be achieved by a number of known chemicals. Probably until the midst to the twentieth century tanning was performed mainly by substances derived from vegetables such as oaks, chestnut, sumac, quebracho, tara or mimosa with processes that required a long processing time with often non satisfying quality. Often these agents were combined with other tanning agents. The technical problem here is often to ensure an invariant concentration of the tanning agent from a natural source to guarantee reproducible processes and leather qualities.

Nowadays, the processes have been much further developed to overcome previous limitations in quality, reproducibility and processing time. Since the growing mining industries made metal salts available on the chemical market with competitive prices, nowadays ca. 85 % of leather goods are tanned with chrome salts. Currently, ca. 95% of shoes, ca. 70% of upholsteries, ca. 100% clothing on the market are obtained by chrome treatment. Chrome tanning is considered to be faster and more versatile for the tanner, because the resulting so-called wet blue intermediate product can serve to make virtually all kinds of leather. Furthermore, the leather product is lighter because the chrome does not fill the leather as is the case with other tanning materials.

However, chrome tanning has come under debate because in some leather goods chromium (VI) compounds have been found, which are associated with health concerns (3). In the conventional chrome tanning process chrome alum ($Cr_2(SO_4)3 \times K_2SO_4 \times 24\ H_2O$) is employed, which is a chromium(III) compound and not a chromium(VI) compound and has no comparable health issues. Products containing excessive amounts of Chromium(VI) are usually withdrawn from the market, and rejected at the borders.

Scientific investigations revealed that the chemical conversion from chromium(III) to chromium(VI) may occur in a post tanning step if tanning conditions were not carefully controlled (4). Other sources discussed are contamination of chemical raw materials, metal-containing dyes, and pigments (5). Thus, from a chemical point of view, non-ideal conditions in some tanneries, i.e. lack of quality and low performance in the process of selected tanneries, appear to be the main factor for undesirable chromium(VI) in leather products and not the process in itself.

Chemically bound chromium, which cannot be released, and free chromium can be detected in leather products. The chemically unbound chromium(III) can in principle be oxidised to chromium(VI), the conditions necessary for this are being investigated. Compared to the large amount of leather currently produced, it seems that only few cases of chromium(VI) formation have been observed, which could mean that improper processing steps are probably responsible for chromium(VI) detection, rather than certain storage conditions.

However, there are indications of how tanning steps can be improved to minimise chromium(VI) formation (5).

Another aspect is the fact that chrome salts are produced by mining industries based on chromite minerals. However, in the framework of current discussions on sustainability, mining processes in general have come under debate because mining processes are difficult to perform under environmentally benign conditions, in particular in less developed countries.

However, chrome tanning is steadily improved. One example is high-exhaustion tanning, which mimimises the amount of chrome that is usually washed out with effluent streams, thereby improving the total environmental impact of the process. This measure has a considerable immediate effect, given that in a standard process around 60% of the chrome tanning agent is bound to the pelt and 40% is washed out to the effluent. The effluent should subsequently be treated in appropriate waste water treatment plants. In modern tanneries, the chrome of the effluent is partly recycled.

But there are alternatives to chrome for tanning. Some of them have been known and established for a long time (see above). Other metals such as titanium, zirconium, zeolite based chemistry, iron are also known to be applicable and developments for new tanning agents are progressing. Some of these, like zeolite-based chemistry (heavy metal free), are supportive in developing leathers that can be composted. Most of the bigger chemical suppliers offer alternatives to tanneries, which have to develop tanning processes to achieve the desired quality. Synthetic chemical tanning agents are available and were originally developed to support vegetable tanning. These substances are based on polyphenolic compounds, partly known from the vegetable tanning. Aldehyde structures are also in use. Probably the best known and most widely applied substance is glutaraldehyde, which is able to efficiently cross-link. Advantage of this substance is its high reactivity, so that no residues remain in the leather, the disadvantage is that requirements for safe handling the substance in the tannery are higher. Nowadays, olive leaf extracts, mimosa and other vegetable extracts with better process adaptions are often used by a number of tanneries. Furthermore, chemicals from renewable resources as well as easier recyclable material are being investigated.

Other leather fabrication steps involve chemicals as well. Previously, hides were conserved by excessive amounts of salt (NaCl), which had to be washed off and led to excessive amounts of salt containing waste water. At least in Europe, refrigerating hides are nowadays more common as conservation method or alternatively the use of dilute saline water, which imposes fewer requirements for wastewater treatment at tanneries. However, in general detergents, enzymes and sometimes biocides may be applied if a more robust conservation of the hides is required at this stage of the process.

The leather fabrication starts with unhairing and liming of the hides. Both steps are traditionally combined, but are increasingly conducted separately. Mechanical removal of hair is often chemically supported by sodium sulfite,

calcium hydroxide and enzymes. The following fabrication steps of deliming and bating are intertwined. The lime is removed with water, sometimes by various acids, while bating uses enzymes, traditionally derived from animal or botanical resources. Pickling is employed to prepare the collagen for the subsequent tanning step, traditionally done by treating it with salt and sulfuric acids. Dyeing, of course, involves the use of dyeing agents. Here in particular aniline dyes are in the stage of replacement. Fat-liquoring consists of lubricating the leather with partially sulfated or sulfonated oils. Drying the end product can affect the total carbon balance of the manufacturing, depending on the energy source.

It should be noted that there is a large variety of manufacturing processes using different types of chemicals in different concentrations and for different durations of treatment. The main challenge in tanning and associated processes is to produce a desired and defined quality. The quality of the product is not necessarily the same for all tanning agents and sometimes additional or modified treatments are required.

In addition to the quality of the goods, the evaluation of a particular process would also require an assessment of the complete fabrication steps and their impacts on the environment (6). For example, the employment of a particular tanning agent may require a higher amount of water, which then needs to be treated appropriately in wastewater treatment plants or would otherwise lead to a hazard. The results of an assessment thus depend on the process itself as well as the assessable plant equipment.

A number of exemplary assessments of particular aspects are available (Panko et al. 2017). Based on assessment of selected key performance parameters, a number of certificates have been created. On the one hand, a detailed analysis of the procedure behind a particular certificate is necessary to weigh up whether a certain certificate meets a particular demand. On the other hand, detailed life cycle assessment approaches have been developed for other industries such as the chemical industry, which can serve as a blueprint for the assessment of the leather fabrication (7). One recent example is the development of a ECO2L, a label for energy efficiency and CO_2 (8). However, many more fundamental approaches are hardly applicable because the required physical quantities for the raw material are not always available from the suppliers of the tanneries. For a more comprehensive assessment, a simplified life cycle analysis would therefore be desirable. Consequently, work is proceeding at Hochschule Darmstadt to develop a tool which covers economic, environmental, health, safety, and social impacts of leather manufacturing steps which may serve as a decision guideline between two potential alternative processes with respect to sustainability.

Sustainability aspects of the manufacturing of leather chemicals

The manufacture of leather goods requires the employment of a number of chemicals. Making leather manufacturing more sustainable should thus also include improvement of the manufacturing and handling of chemicals employed.

In the chemical industry, the shift towards more sustainability already began a long time ago. Green chemistry & -engineering concepts are no longer purely scientific approaches and are increasingly finding their way into production. Continuous improvement and active environmental management have become part of companies goals (see e.g. ISO 14001[1]). In addition to the positive aspects of the (self-imposed) environmental goals, such certification can of course also be used as a marketing advantage and thus increases the pressure on competitors. But also on a scientific level, sustainability assessment methods are constantly further developed, demonstrated for example recently in an article from Hessel et al. [9].

[1] **ISO 14001**
https://www.iso.org/iso-14001-environmental-management.html

In a parallel project[2] to this design handbook, work is being carried out together with stakeholders from the leather sector to develop a sustainability assessment tool that is specially adapted to the processes of the leather industry. On the one hand, such tools could help companies to identify improvement possibilities and eventually reduce their environmental footprint, and on the other hand to report their impacts and actions. Designers could take a look at such reports to evaluate or compare the sustainability of the materials of interest.

[2] **see subproject on Chemical and Process Innovation:**
https://sne.h-da.de/en/implementation-project/more-sustainable-chemistry-in-the-leather-supply-chains/subprojects-as-pathways-to-solutions/chemical-and-process-innovation

The production of chemicals generally requires a large amount of resources and energy. Modern concepts of process engineering, such as process intensification, can help to make the manufacturing process of a chemical more sustainable (for references to this topic see e.g. [10, 11, 12]). A number of technologies have been developed to support efforts of process intensification and green engineering. In particular, micro-process engineering and the transfer from batch to continuous operation (flow chemistry) enables a number of chemical reactions and processes to be performed more effectively with reduced energy requirements and less waste production. One example is the reduction of solvent consumption due to improved heat transfer of the apparatus or the replacement of solvents by less environmentally harmful ones. Usually, solvents have to be removed from the product in a complex and energy-intensive manner, so smaller amounts and proper selection will reduce the overall energy requirement.

Other advantages of continuously operated micro-processes are the smaller reactor volumes and the almost completely closed production method, which is safer for employees and the environment, since no or, in the worst case, only a very small amount of chemicals can be unintentionally released to the environment.

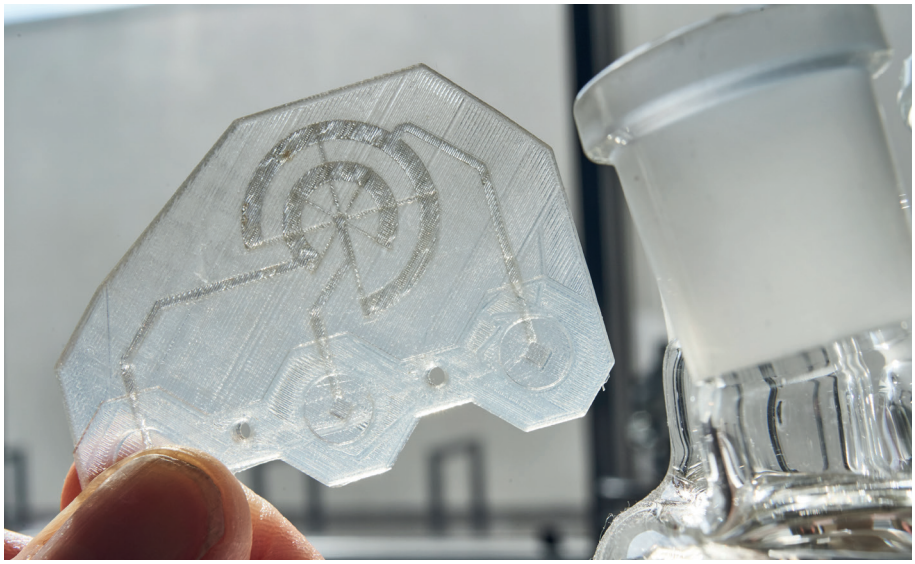
Furthermore, flow chemistry typically uses online process control, so process parameters can generally be adhered much more precisely than with less modern process methods. This leads to consistent product quality, less waste and enhanced safety. In addition to these advantages, new, more extreme process windows can be achieved that are not accessible with conventional techniques. These include, for example, very high pressures and both very high and low temperatures, which allow chemical reactions that cannot otherwise be performed on a technical scale.

Fig. 3.3.2) Micro-reactor setup
(Photo: Jens Steingässer, 2020)

Nowadays, chemicals are often produced in large plants at a few locations around the world and then transported to their destinations while releasing a high level of CO_2. Smaller plants of this type are difficult to operate profitably. Here, micro-process engineering / flow chemistry enables the new approach of decentralised production. Many small-scale production plants can be distributed in many locations around the world, which means that subsequent transport is significantly shorter and therefore more environmentally friendly. Chemicals can be produced on site and on demand.

The conversion from conventional production processes, or partial steps of them, to processes of micro-process engineering or flow chemistry could therefore contribute in the long term to a more effective and thus more sustainable production of chemicals.

Fig. 3.3.3) 3D-printed micro reactor / micro chip
(Photo: Jens Steingässer, 2020)



Another approach to make the production of chemicals more sustainable is to switch from fossil raw materials to renewable ones (for selected references see e.g. [13 & 14]). On one hand, with the use of fossil raw materials, CO_2, which was initially bound in, e.g. crude oil in the earth, is sooner or later released into the atmosphere. When using biomass, on the other hand, only the CO_2 that the plant has previously absorbed from the environment would be released, which would, in the best case, create a CO_2 cycle (of course, further requirements such as the use of renewable energy for the chemical production process has to be considered, etc.). Biomass-based platform chemicals, from which a number of secondary products can be manufactured, are currently being intensively developed, with the transformation to a bio-based chemistry already underway, and some bio-based chemicals already available on the market. Nevertheless, a lot of research and development work is currently taking place here and it must be checked whether the production process of chemicals in the leather sector can be converted to biomass as the raw material or whether completely new chemicals and production processes need to be developed.

In the end, chemicals are beside other factors decisive to the appearance, properties and quality of the tanned leather. Even if the designer has no direct influence on the production methods of the chemical companies, he still influences which chemicals are used more often by choosing a more "sustainable" leather. Assessment tools, in which the chemicals used are reasonably considered and the publication of the gained results will hopefully make it easier for the designer to identify a more "sustainable" leather in the future and therefore also raise the demand for more sustainable chemical production processes.

From Green to Sustainable Chemistry

Several decades ago, the concept of **„Green Chemistry"** was introduced to support the use of better and safer chemicals – with less adverse effects. In recent years, it has evolved into the broader concept of **„Sustainable Chemistry"**, which is closely related to the Sustainable Development Goals of the global Agenda 2030 process.

Both visions have the use of chemicals in common which are safer and have less or no adverse effects compared to the currently used chemicals. The main additional element of sustainable chemistry is that it includes aspects of social responsibility and asks for the contribution of chemicals to a better and more sustainable world as it is today. The following 100 words describe in a nutshell what sustainable chemistry means:

"Sustainable chemistry contributes to positive, long-term sustainable development. With new approaches and technologies, it stimulates innovations and develops value-creating products and services.

Sustainable chemistry uses approaches, substances, materials and processes to deliver functionalities. Therefore, it uses substitutes, alternative processes, resource recovery and efficiency. Thus, it avoids rebound effects, damage and impairments to human beings, ecosystems and resources.

Sustainable chemistry is based on a holistic system approach, setting policies and measurable objectives for a continuous process of improvement. Interdisciplinary scientific research, education, consumer awareness as well as corporate social responsibility and sustainable entrepreneurship serve as an important basis for a sustainable development."

Criteria to check the sustainability of chemicals are described in the "Guide on sustainable chemicals" (UBA 2017).

FOCUS BOX 1: The Guide on Sustainable Chemicals

This guide helps enterprises to assess the properties of chemicals and to select better and safer substitutes for problematic substances. It uses eight criteria which refer to intrinsic properties of the chemicals. A second set of criteria takes the function and the use of the chemical into account. The guidance addresses well-known aspects such as worker protection as well as further aspects of sustainability, e.g. social responsibility in the supply chain. It is available for free. In addition to the printed version, the criteria can be used in an electronic, access-based version ("SubSelect"). For more information, see

https://www.umweltbundesamt.de/en/publikationen/guide-on-sustainable-chemicals

The challenge to change from regrettable substitutions to sustainable substitutions

Frequently, substances restricted by law are replaced in the production process by substances with a similar structure. Examples are substitution of Bisphenol A by Bisphenol S or long-chain per- and polyfluorinated chemicals (PFCs) by middle- and short-chain PFCs. This has the advantage that often no or only minor changes of the process conditions are needed. However, it has the big disadvantage that the substance frequently has adverse effects, too. Such a „drop-in" substitution is called a „regrettable substitution". A few years later, the substance has to be replaced again.

Sustainable chemistry calls for "informed" substitution – solutions which are truly better and safer in the long run. They focus more on the function which is needed than on a particular chemical structure. Often, changes in the process or in the design of the final product allow for better and more sustainable solutions.

How to find Sustainable Chemicals?

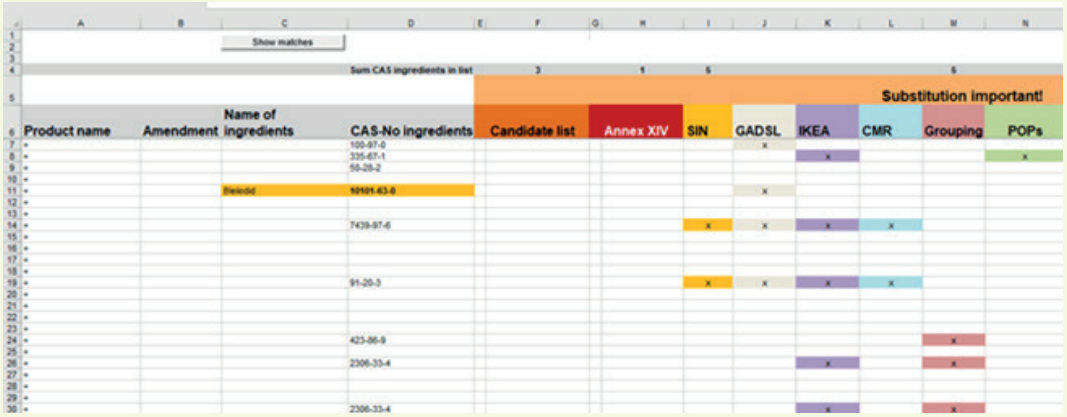
The concept of sustainable chemistry needs transformation into the day-to-day decisions of production processes. This includes, at first, the assessment

of alternatives for chemicals with problematic properties and processes with problematic emissions. These assessments require technical experts who are familiar with the production processes and the required performance properties of the final leather products.

Sustainable leather chemicals are developed in global supply chains. Within Europe, the best available techniques for leather production are currently described in the BREF documents. However, being published in 2013, more recent developments are not covered in this report. Multi-stakeholder initiatives such as the Leather Working Group (LWG) assist tanneries in finding the best-in-place solutions available on the market. Companies can use platforms such as ChemSec Marketplace to find and ask for the most advanced solutions for a specific process. Companies can check whether they are using problematic chemicals using publicly available tools such as the US EPA GreenScreenListTranslator (see http://www.oecdsaatoolbox.org/Home/Summary?summary=t17), the EU portal SUBSPORT Plus [see https://www.subsportplus.eu/subsportplus/EN/Home/Home_node.html.) and the screening tool REACH Radar [see FOCUS BOX 2].

FOCUS BOX 2: The Screening tool REACH Radar

REACH Radar is an early warning system for chemicals management. The simply structured Excel application helps companies to quickly identify whether substances they use are already on the REACH candidate list or other lists of problematic substances and for which substances restrictive regulatory steps are to be expected. The main structure of REACH Radar is shown in the following figure.



REACH Radar is freely available at www.oeko.de/reach-radar.

The ZDHC is focusing on their Manufacturing Restricted Substances List (MRSL), which is eliminating hazardous substances from the leather value chain by driving this chemistry from brand requirements. Within the ZDHC,

the industry collaborates to further improve chemistry and ensure cleaner wastewater and safer chemistry for workers and the final consumer. Next to this, the ZDHC is working with LWG to optimise the positive impact of both programmes.

How to Include Sustainable Chemistry in Leather Design?

Designers of leather products decide which raw materials to buy. They can include considerations about the care of the final product in their design criteria. There are several key options to ensure that more sustainable and innovative chemicals are used:

- Leather and other materials used for the production of the leather product should fulfill demanding ecological and social requirements similar to those set by product labels such as the EU Ecolabel or the Nordic Swan.
- Suppliers of the raw materials should ensure that they do not use substances with adverse effects as far as possible. If the use of such substances is unavoidable, they must strive to reduce emissions as much as possible and look for less problematic alternatives.
- They should demand chemistry that is compliant with the ZDHC MRSL.
- They have the chance to ensure that the final product can be cleaned and polished with care products which are free of problematic substances. They can motivate their customers to e.g. PFC-free care products.
- As shown above, sustainable chemistry includes fair working conditions along the supply chain. Therefore, good design practice also means to establish and maintain long-lasting and fair relations with suppliers and customers. Criteria for this are also included in the above-mentioned "Guide on Sustainable Chemicals" (see info box 1 above).

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3.4
Policy Impulses from the EU Green Deal

Julian Schenten

Designing Leather Products in a Dynamic Policy Environment

New policies and regulatory initiatives, both in different regions of the word (e.g. EU Green Deal) and at global scale (UN SDGs, UNGP), as well as consumers and NGOs are putting pressure on – and at the same creating oppurtunities for – the leather industry and downstream businesses (fashion, footwear, furniture etc.). Companies need to develop and market products that are safe for consumers and meet the goals of a circular economy (durability, reparability, reusability etc.). Besides, companies need to ensure due diligence of all environmental and social impacts, including impacts on worker health, along the entire supply chains. In some regions, the EU in particular, one can observe quite dynamic legislative developments.

Fig. 3.4.1) One of the critical aspects along the global leather supply chains is the appropriate treatment of waste and waste water Photo left: inappropriate drainage of wast water (photo: SÜDWIND-Institut, 2020); Photo right: Proper treatment of waste water (photo: HELLER-LEDER GmbH & Co. KG).

Regulation has a direct impact on the design of products and production processes. Design needs to take into account legal criteria defining the conditions under which a product may be placed on the market. Beyond legal minimum requirements, normative impulses create leeway for competitiveness by design. This holds particularly true in periods of political transition. The European Green Deal (1) is one central hallmark of such transition – that is

attracting international attention. First, because EU policies create a global impetus, i.e. often inspire similar legislation in other regions (2). Second, the European Union is the second-largest consumer market after the United States (3).

Against this background, this chapter aims to outline selected elements of the Green Deal that are relevant to leather products and production conditions (global supply chains). Subsequently, it sheds some light on the implications of these elements for the designers of leather products, particular in terms of more sustainable leather chemistry.

Some relevant policies set out by the Green Deal

The EU Green Deal (1) aims at "Transforming the EU's Economy for a sustainable future" (p. 4). A resource-efficient "clean and circular economy" (p. 7) capable of avoiding risk cycles of (leftover) substances of concern is a key component of this transformation. The Green Deal and subsequent policies (inter alia Chemicals Strategy for Sustainability, Sustainable Product Initiative) comprise various mechanisms and instruments, tackling product design, transparency about product' performance and impacts (digital product passport), consumer empowerment, supply chain due diligence, green procurement and green finance among other things to facilitate this transformation. A resource developed and maintained by researchers at the Darmstadt University of Applied Science aims to provide an overview of the different Green Deal policy fields and their various interlinks (4).

NOTE:
The following sections are referring to the available information as of September 2022, i.e. political strategies and legislative drafts. While providing a plausible overview of how EU's products policies might look like tomorrow, these documents do not allow us to draw conclusions as to the contents of the final legal acts as adopted by the relevant legislative bodies.

Overview of Sustainable Product Policies

The Circular Economy Action Plan (CEAP) calls for establishing a Sustainable Product Policy Framework (5). In September 2019 the Commission launched an Inception Impact Assessment on the Sustainable Product Initiative providing a roadmap on planned advancements of the policy framework and additional policy options (6). According to the document, "the scope of the Ecodesign Directive needs to be widened beyond energy related products, and made applicable to the broadest possible range of products" (p. 1, see the next section). The goal is to set criteria "at EU level of appropriate minimum sustainability and/or information requirements for specific groups of products" (p. 3). Textiles are among those product groups and so are furniture, hence, product groups related to leather (see the "Sustainable Textiles Strategy"

below). In the initiative, the following additional measures, among others, will be considered – all bearing relevance to the context of leather products:

- **Establishing EU rules to make producers responsible for providing more circular products and intervening before products can become waste (for example providing products as a service, providing repair service/or ensuring spare parts availability).** Being manufactured from a by-product from the dairy and meat industry, the material leather by itself contributes to circularity. Circular Economy however does not end here. The sector will have to think about design techniques and business models on how to keep leather in the material cycles, either by prolonging product life or by finding new use cases for the material after the product life ends. Chapters 4.1 and 4.2 provide guidance in terms of reusability and recyclability.
- **Establishing EU rules for setting requirements on mandatory sustainability labelling and/or disclosure of information to market actors along value chains in the form of a digital product passport.** The Digital Product Passport for leather products (see also below) could inform consumers about the origin of the hide and other materials, chemicals contained in the product (e.g. from finishing of surfaces) and about maintenance/care options to keep the product quality.
- **Measures of production processes, e.g. to facilitate recycled and remanufactured material and to track the use of hazardous substances in such processes.** As stated above, any leather by definition contains recycled content. To allow the remanufacturing of leather, it will be necessary to grant relevant actors at the end of life access to information on the chemicals contained in the material. Based on this information, they can determine the possible future use cases for the material. The Digital Product Passport could be that medium to carry such information.

Draft "Ecodesign for Sustainable Products Regulation"

On 30 March 2022, the Commission specified its vision of a "Circular Economy" in the area of product policy with a package of proposals "to make sustainable products the norm". At the centre is the proposal for a regulation defining a framework for ecodesign requirements for "sustainable products" (Draft Ecodesign for Sustainable Products Regulation – ESPR-D, see (7)). The ESPR-D is intended to remove the limitation in scope of the current regime (Directive 2009/125/EC) to "energy-relevant products" and thus create the possibility, with a few exceptions (e.g. food and feed, medical devices), to establish ecodesign-related requirements in principle for all physical product groups e.g. for textiles and potentially for leather products (see below). This is done by enacting specific legal instruments (delegated acts).

Delegated acts stipulating ecodesign requirements can target improvements of the product aspects listed in Art. 5 of the ESPR-D. Most of these aspects relate to Circular Economy business models (durability, reliability, reusability etc. but also presence of substances of concern, and environmental impacts).

These aspects can be subject to performances requirements (Art. 6) and information requirements (Art. 7).

The Commission may design delegated acts based on what is needed in any given product group. However, the draft regulation also defines some minimum content of the delegated acts. E.g., pursuant to Art. 7(2)(a) of the ESPR-D the information requirements have to include "requirements related to the product passport" (see below) and "requirements related to substances of concern". The latter, according to Art. 7(5) of the draft, "shall enable the tracking of all substances of concern throughout the life cycle of products", including the name, location and concentration of the substances of concern present in the product. This shall contribute to the goals of the ESPR, see e.g. Recital 8 of the draft: "chemicals, materials and products have to be as safe and sustainable as possible by design and during their life cycle, leading to non-toxic material cycles".

Chapter 3.5 on chemicals traceability describes an IT-based management approach that companies can implement to control all chemicals contained in their (leather) products. One major benefit of this approach is that, once the chemicals contained in products are mapped, users of such systems will be able to evaluate "just in time" whether any update of the SVHC list (or basically any new regulation concerning chemicals) is relevant for their business, as they now have to follow the transparency rules outlined above.

Digital Product Passport

In the interplay with additional Green Deal policies, the Digital Product Passport offers information-driven potential to promote the transformation of economic sectors towards more sustainable products and consumption (8). The ESPR-D establishes the legal basis for the Digital Product Passport in the context of eco-design. According to the regulation's draft, it will be mandatory to stipulate the provision and implementation of the DPP in future ecodesign delegated acts (see previous section). Chapter III of the ESPR-D as well as its Annex III provide basic requirements for the DPP, while its role and functions may change related subject to the delegated acts and the specific product groups' needs.

In the – hypothetical – example of a DPP for leather products many use cases along the value chains are conceivable. For instance, producers could exchange B2B certificates proving the origin of the hides or the quality of other raw materials. They could furthermore meet legal reporting obligations by using the information channels to authorities established by the DPP. The DPP may also ease public agencies' tasks in the context of market surveillance. Manufacturers could educate consumers on care measures to enhance durability of the products and provide contact data of business partners in case repair serves are required. Besides, consumers could access verified product information.

EU Strategy for Sustainable and Circular Textiles

The "EU Strategy for Sustainable and Circular Textiles" was published on 30 March 2022 (9). It addresses a comprehensive "Textiles Ecosystem" including the clothing, leather and footwear industries. Without further specifying the product scope, it provides for the adoption of a delegated under the ESPR with binding eco-design requirements. These will be aimed at, among other things, longer durability, preferred material compositions and the presence of substances of concern.

Chemicals Strategy for Sustainability

Already in October 2020, the Commission launched the Chemicals Strategy for Sustainability (CSS), formulating a long-term vision for the EU chemicals policy based on a new "Toxic-free hierarchy" in chemicals management (10). This hierarchy prioritizes the promotion of safe and sustainable chemicals over the minimization of exposure and risk control and the last resort of disposal (e.g. of contaminated wastes) and remediation. Each of the three levels include specific elements aimed both protecting human health and the environment and encouraging innovation (Figure 3.4.2, ibid).

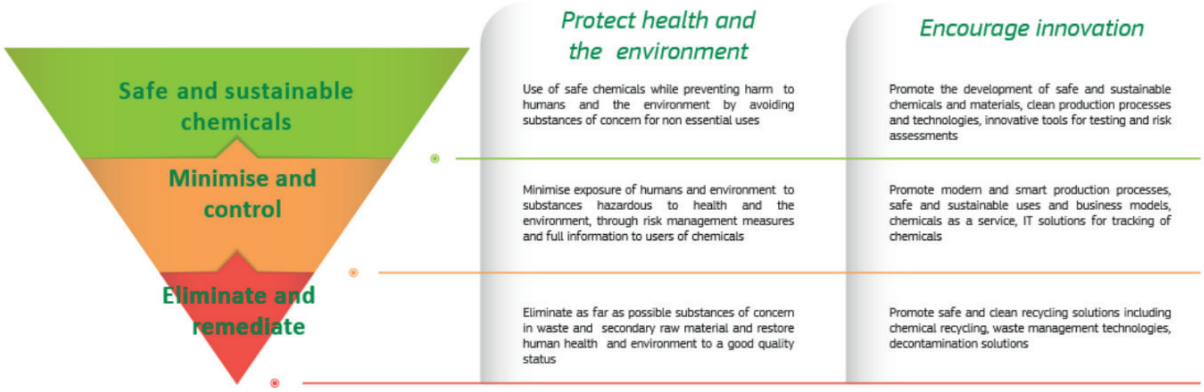

Figure 3.4.2: Toxic-free hierarchy as introduced by the CSS

The CSS entails a large number of policy measures, which are also relevant for the leather sector. On the one hand, safe and sustainable-by-design criteria for chemicals will be developed. On the other hand, new REACH restrictions will be enacted prioritising several classes of problematic substances, i.e. carcinogenic, mutagenic and reprotoxic substances (CMRs), endocrine disruptors, persistent, bioaccumulative and toxic (PBT) and very persistent and very bioaccumulative (vPvB) substances, immunotoxicants, neurotoxicants, substances toxic to specific organs and respiratory sensitisers. Additionally, the Commission assesses the introduction of the "essential use" concept, implying that "most harmful chemicals are only allowed if their use is necessary for health, safety or is critical for the functioning of society" (p. 10). Both perspectives will create incentives for manufacturers of leather chemistry to formulate new chemical products, which will certainly have an impact on the leather products.

Responsibility in the Supply Chains

The Green Deal underlines the Commission's commitment to the transformation of global value chains, by promoting new standards for sustainable growth. Against this background, a legislative proposal of February 2022 for a Directive on "Corporate Sustainability Due Diligence" (11) aims to improve the due diligence of brand owners ("brands") and retailers on the environmental and social impacts of activities along supply chains. Similar rules are already in place in countries such as France (French Duty of Vigilance Law) and Germany („Lieferkettensorgfaltspflichtengesetz"). Under the 2021 draft, in general, companies with more than 500 employees on average and a net worldwide turnover of more than EUR 150 million are falling in the scope of the draft. However, the draft lowers the threshold for certain "high-impact" (Recital 22) sectors, including the manufacture of textiles, leather and related products (including footwear), and the wholesale trade of textiles, clothing and footwear.

In addition, the Commission launched in November 2021 a legislative draft tackling deforestation and forest degradation (12) by regulating the placing on the market of certain potentially problematic goods, including leather of cattle (13).

Implications for design, with a focus on chemicals

The policy developments outlined in the previous section are relevant for the design of products and processes. In this respect, some basic rules can be derived. First and foremost, design must not result in non-compliance. In addition, smart design approaches help achieve requirements effectively and efficiently. In both respects, depending on the specific requirement stipulated or anticipated, the design principles from Chapter 4 may come into place.

The Green Deal puts a lot of emphasis on the circularity of products and on related concepts (e.g. repairability). There is thus a need for designers to identify materials and techniques supporting circularity. In addition, design for circularity entails the capability to avoid "risk cycling" due to chemicals of concern present in leather. These so-called legacy chemicals constitute risks because they could be released to the environment at the end of life or, in case of material re-use or recycling, "smuggled into" new materials.

As for the challenges linked to chemical substances, an example of smart design is the proactive substitution of chemicals that are subject to legal requirements or projected to be regulated. In this respect, substitution should go beyond simply replacing a regulated (e.g. banned) substance by a structurally related substance. While in the short term this strategy might appear attractive as it implies little impact on the overall production process, it might turn out insufficient in the long run. This is because in this scenario, it is rather likely that the substitute substance causes negative impacts as well. This would not be in line with the objectives of the Green Deal. Also, it is

rather likely that the legal effect of the ban would be extended to the substitute substance. In fact, by moving from case-by-case decisions to grouping, regulation will get more effective. For instance, the first group restrictions under REACH have been adopted; the CSS also calls for grouping approaches (see the examples above). Sweden and France are currently preparing a restriction on the placing on the market of textile, leather, hide and fur articles containing more than 1.000 skin sensitising substances (14).

The regulatory grouping approach is therefore a driver for more innovative alternatives, including non-chemical alternatives, and may thus spark designer's creativity. The designer should ask what is the best method to ensure a certain desired product function, instead of how to substitute chemical x with chemical y. Interdisciplinary cooperation with material experts or chemical risk managers is key here. Designers must not neglect these issues in the first place by only focusing on aesthetic features alone.

Such reformulations of products are often perceived more costly, which does not need to be the case in the long run (and if environmental costs are internalised). The design methods introduced in chapter 4 could provide ideas for non-chemical alternatives, as well.

In practical terms, there are useful tools available free of charge, that support designers: Search for alternatives regarding chemicals of concern, or insert an ad in this respect at https://marketplace.chemsec.org/Alternatives

Moreover, designers in general should develop strategies to avoid substances that may become subject to legal requirements. A generic risk approach would be most effective. It implies avoiding chemicals based on intrinsic hazards that are not (any more) accepted in EU societies.

Considering the entire product life-cycle the mere hazard of a substance already implies a certain risk, because exposure cannot be fully avoided which might expose certain vulnerable groups of the population. While it might be possible in (certain higher level) production settings to mitigate or even avoid exposure by employing adequate OHS [Occupational Health and Safety] measures, this might not be the case in all production settings. Besides, it is next to impossible to anticipate all potential conditions of use by consumers, thus increasing the likelihood of exposure. Similar, after disposal exposure often cannot be ruled out. In conclusion, since exposure cannot be deemed negligible presence of hazard may constitute a generic risk (in contrast to specific risk that is determined in a more lengthy process in the context of actual products in actual exposure scenarios).

Such a strategy would need to address widely "outlawed" contaminants such as CMRs, sensitisers, PBT and vPvB substances as well as additional substance groups targeted by the CSS (PMT, EDC, neurotoxins etc.).

In practical terms, there are useful tools available free of charge, that support designers: Identify future chemicals of concern, i.e. all substances that fulfill the SVHC criteria, https://sinlist.chemsec.org/

In terms of identifying more sustainable chemistry, the criteria developed under the CSS could provide guidance to the extent that they will allow the identification of chemicals that are considered safe.

Putting designers in the position to more actively control the substances that end up in the products is another approach. A company that has established an IT communication scheme that enables the traceability of chemicals in materials (and perhaps in processes) helps designers to identify unwanted substances and thus potentials for improvements (cf. chapter 3.5). This would allow the designer to proactively drive products and processes towards sustainable development. They could also consider how the tracked information can be used for communication and conceptual design. In this way, legal requirements can also be perceived as creative impulses that can be used creatively to invent new concepts and business models that are beyond compliance.

Forward-looking companies are examining what impact the legal developments outlined in section 1.1 may have on their business models. Complex legislative matter, such as aspects of sustainable development, require a systemic view of regulatory framework conditions that are in place, as well as potential legal changes.

However, as far as the responsibility of designers is concerned, it is worth noting, that until today it is reasonable to assume they are more or less ignorant of aspects related to chemicals or at least do not adequately consider such aspects in the design process. There is also a lack of communication between the departments within a company that are in charge of design, of quality and of environment and safety issues. What is needed here is, first of all, more interdisciplinarity and an awareness among designers that they can have a positive influence – namely by making aesthetic and conceptual decisions from a systemic perspective in consultation with other disciplines in the team. This then naturally includes the legal framework and the issues surrounding chemicals in the context of leather.

More practical tools for designers are introduced in chapter 3.3 on chemicals.

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3.5
Traceability and Information Management

Eleni Kaluziak, Julian Schenten, Deborah Taylor

In Short

Traceability creates opportunities for designers by providing actionable information. At the same time, traceability has an impact on the design. When thinking of leather products, e.g. a shoe or a car seat made of leather, it is important to know, where the leather has come from, how it has been processed and what durability and performance can be expected, among other things. Do these products meet customers' expectations, the brands' sustainability visions or legal requirements? And finally, yet importantly, how can leather products be repaired or recycled? This is not only about the leather hide, but also about all the other components that make up a product like a shoe – shoelaces, metal parts, plastic components, rubber, etc.

Traceability is the key to gathering valuable information:

- **Better informed product design: designers identify materials with unwanted environmental or social impact and can improve or substitute them.**
- **New business models linked to product design (circular economy): traceability may allow designers to select secondary materials that fit specific design needs.**
- **Traceability leaves traces on the product or its packaging (such as the QR-codes on the packaging of some food brands that are well known by consumers). The designer can make use of this.**

Achieving traceability and transparency has become more and more of a priority in the garment and footwear sector in recent years. Negative impacts on human health, human rights and the environment resulting from such businesses are monitored and made public by NGOs and the media. This is consequently creating an increasing awareness among consumers who are demanding enhanced visibility of raw material origins and the production processes involved in the products they buy. Also, consumers want brands to show responsibility for what they sell.

Multiple sustainability risks become apparent with regard to the leather industry (see chapters 1.1 & 2.4). These start with livestock/animal welfare, deforestation, land use conversion, biodiversity aspects and ecosystem depletion, chemical use, environmental pollution, occupational health and safety as well as employment conditions ((forced) labour, wages etc.). Moreover, compliance with legislations along the product life-cycle (e.g. laws on environment production or product safety), and legal-ethical aspects such as corruption play a huge role.(1)(2)

However, companies are generally not in a position to exactly identify, assess and subsequently declare what materials their products contain, nor where they have originated. Complex supply chains across different countries with different national practices, political and regulatory framework conditions, as well as working conditions make it difficult to provide clarity.

IT traceability tools underpinned with sector-wide, hence internationally, agreed standards for the collection and reporting of data to track and trace materials and processes (governance framework) provide a solution.

Designers can use the information and data collected that way to make valuable decisions on product designs. Moreover, they will be better equipped to make the decisions based on criteria such as longevity and sustainability.

Definition of Traceability

There are many definitions in place about traceability, e.g. traceability is "the ability to verify the history, location, or application of an item by means of documented recorded identification" (3). The key function is to collect and maintain data on the product characteristics and history and to be able to trace this information along the supply chain. A traceability system is a system that records and follows the trail and path along the supply chain from one supplier to another.

Relation to transparency

Transparency, in contrast, can be defined as "relevant information being made available for all elements of the value chain in a harmonized way, which allows for common understanding, accessibility, clarity and comparison"(4). A tiered approach to transparency, that takes the required information by different stakeholders (e.g. consumers or recyclers) into account is also conceivable. Traceability provides the backbone for any transparency measures.

Traceability of hides

Designers may want to select special leather hides qualities, from special regions and husbandry conditions, for different product features and functions. Besides the qualitative aspect, this could be relevant to support the story of a particular product.

Tracking, monitoring and verifying the leather-hides through their value chains is quite complex. Leather may originate in Brazil, be further processed in Asia, before being finished in Europe and then shipped to India for the manufacture of a product before the product is sold worldwide. The leather needs to be marked to be recognized and tell its history.

Traceability of other materials

Returning to the example of a shoe, the different single components of a product also need to be traced back. This starts with a chemical finish that usually covers the surface of leather. A shoe's chemistry is therefore a crucial aspect in designing products that are safe for humans and the environment.
A majority of brands lack understanding of what chemical substances are contained in their leather products or used during the manufacturing processes in their specific supplier factories. After all, there is no IT-Tool or governance framework in place for such traceability and alternative approaches (e.g. Restricted Substances List - RSL) are not always completely effective.(5)

Chemicals play a big role. How can designers make the right choices?

Why Traceability is the Key

Companies must ensure that they are only place leather articles on the market that are safe. Besides, subject of the EU "Green Deal" policies, the frameworks that govern the production and import of leather articles will put more emphasis on eco-design and the goal of a circular economy. Moreover, companies need to prepare for legal obligations that demand their responsibilities regarding the social and environmental impacts of operations along their supply chains (see chapter 3.4 on policy aspects).

Thus, the chemicals used in the various production steps play a crucial role, both as a risk and as an enabler for more sustainable products and processes. Suitable IT tools are necessary for communication and control processes along the supply chains to obtain information on chemical ingredients, production processes, supplier data and evaluation. In addition, a governance framework is necessary to define the rules, ensure the quality of data and to secure intellectual property.

Both aspects mentioned before are of high importance for the establishment of sector-wide structures to achieve traceability of chemicals - the benefits are as follows:

- Gain a better understanding of the process conditions in their specific supplier factories
- Allow companies to formulate a more targeted demand for more sustainable chemistry in their supply chains
- Enhance (proactive) strategic and operational decisions

- Enhance corporate risk management
- Meet requirements of customers
- Meet requirements of policy makers aiming at safety and sustainability, and better traceability of chemicals (see the New Circular Economy Action Plan, Chapter 3.4)
- Allow companies to react effectively to cases of liability – and to better avoid these
- Seize market opportunities for more sustainable products
- Secure so-called „green claims"
- Enable the sector's transition to more sustainable chemistry[1]

[1] see also: https://sne.h-da.de/leather-chemistry

Prerequisites

In the following we refer to a categorisation that is also used by Textile Exchange in their webinars.

Types of Tracers

Different types of tracers/identifiers are currently in place, which means that different reading capabilities are needed at the slaughterhouses and the downstream production stages. The following overview gives some examples without making a recommendation.

There are three types of tracers that can be used to mark leather; they can be **in** product, **on** product and **off** product (3):

A.) In product

"In product"-tracers embed the identifier into the product itself at its place of origin, e.g. DNA, dyes, particle markers. The unification can only be dissolved by destroying the product.

Each tracer functions a little differently, e.g. fluorescents: A dye component that is embedded within the manufacturing process; DNA, a molecule embedded into the molecular structure of the product.

B.) On product

"On product"-tracers apply the identifier onto the product at its place of origin and accompanies it as a unit through the supply chain, e.g. RFID, barcodes, NFC, stamps. These tracers can be removed from the product by physical force, chemical process or trimming.

NFC: near-field-communication, which is essentially about a set of communication protocols between different devices, a sort of chip which is sewn on the product and communicates with a mobile device or a scanner;

RFID: radio frequency identification is very similar to NFC, by tagging a chip on the product which allows communication with an external device along the supply chain;

Barcodes: also communicate with an external device.

The following demonstrates how an on product tracer can work via:

Laser technology (6)**:**
From an ear tag or alike, at the slaughterhouse, an animal identification number is transferred onto the hide by laser technology. This identifying number is provided by the farm (via the ear tag or similar) and put on to the raw hide (via the laser replication) where it remains until the finished leather material. The laser mark is sufficient to remain present throughout the thickness of the hide/ skin, so even if the material is split, the mark remains visible.

At each stage of the leather process, the laser identifier can be read for tracking and monitoring. However, the laser mark will be trimmed away before the final product is manufactured.

Example "Leather ID"
The company "JBS360" offers a software system that allows customers to trace hides by using a code that is marked on the hide itself. While the code can be deciphered in terms of date of production and processing unit and tannery (Fig. 3.5.1), entering this code into a website offers more in depth information. However, the code might be removed or damaged during further processing.

Fig. 3.5.1) Illustration of a "Leather ID" lasered into a hide (photo: JBS360; https://jbs360.com.br/en/leather-id/

C.) Off product

"Off product"-tracers put the identifier on a medium that is provided with the product at its place of origin and accompanies it through the supply chain, e.g. certificates, digital trace.

Off product tracers can be IT digital solutions, e.g. Centralized database: this is a more commonly used system that refers to one common place to store the information. All parties along the supply chain combine the information that is stored in one central location and often there is a central governance, monitoring and tracking the information flow. E.g. standard or certificate suppliers would work with a centralized system because they want to be able to monitor and track and maintain the information.

In contrast, with distributed technologies (often referred to as blockchain), there is no central governance. All parties using the blockchain must verify a particular transaction of information on to the chain before it can be accepted within the solution itself as a genuine information. Accompanying visualization tools or platforms can show (transparently) the journey of a product, with several options regarding the granularity of information (e.g. country, region, city, address of the supplier).[2] For all these approaches, there are many solution providers in place.

[2] see for instance the example at https://www.vfc.com/sustainability-and-responsibility/traceability-maps

In this respect it should be noted that leather is cut, split or trimmed into pieces specific to the pattern for the end product being manufactured. This raises a number of questions: how can the on-product tracer be maintained (where no embedded marker is used)? How can the tracing tags be multiplied? How can it be ensured that a product identifier is correctly linked to IT data systems? How can control mechanisms be ensured? These are some of the challenges the industry needs to focus on.

IT-Solutions for Chemicals

In the following, a possible IT solution – the **AskREACH-Tool** is presented. It has been tested in a case study, and is designed especially for tracing chemicals in articles to achieve a full material declaration.

The Darmstadt University of Applied Sciences h_da is involved in researching the **traceability of chemicals** in articles supported by IT tools. It launched a subproject named "IT Tools and Governance for Traceability" under the leather project "More sustainable chemistry in the leather supply chains".

The subproject "IT Tools and Governance for Traceability" focuses on the traceability of chemical substances along supply chains to enable companies to control what substances are in their products and related processes. An IT-based exchange format is needed to trace chemicals, and the data basis must be provided by all suppliers in the supply chains. Further, it is essential that the IT tool is accepted industry-wide through an accompanying governance framework to ensure data quality and intellectual property. The h_da researchers teamed up with Ricosta, a German shoe company which has piloted a supply chain communication tool (AskREACH-Tool) provided by iPoint-Systems GmbH.[3]

[3] The h_da project AskREACH promotes a supply chain communication approach increasing the capacity of companies to meet their obligation to inform about SVHCs in articles. The corresponding IT-Tool is being provided by iPoint-systems GmbH, a provider of software and services for environmental and social product compliance and sustainability.

The AskREACH-Tool as a Material Data System (MDS) allows companies to gather article information from every supplier along the supply chain. Companies can also create Full Material Declarations (FMD), which requires suppliers to report data on all substances contained in articles. The purpose of the MDS is to generate a structure tree of all materials contained in the final end product, which is reportable. The structure follows the different stages in the production process, e.g. from the semi-finished article, further processed component and finally to the incorporation into the end product.

Key Takeaways from the Pilot Study so Far is that:

The AskREACH-Tool can:

- Create a FMD for leather, i.e. substances used - shown via CAS-numbers[4] - can be declared up to 100%.
- Show a bill of material on chemicals for the composition material[5] but also for process chemicals[6].
- Present, which substances/ materials are in products and in what concentration.
- Questionnaires/ attachments on e.g. sustainability aspects such as land use, animal welfare and social criteria can be uploaded.
- Automated signals make aware of regulated substances in products.

[4] "Chemical Abstract Service": an international unique numerical identifier for chemicals

[5] chemicals intended to be present in the product (e.g. coating)

[6] Process chemicals: these are not intended to remain in the finished product (e.g. salt, biocide, tensids)

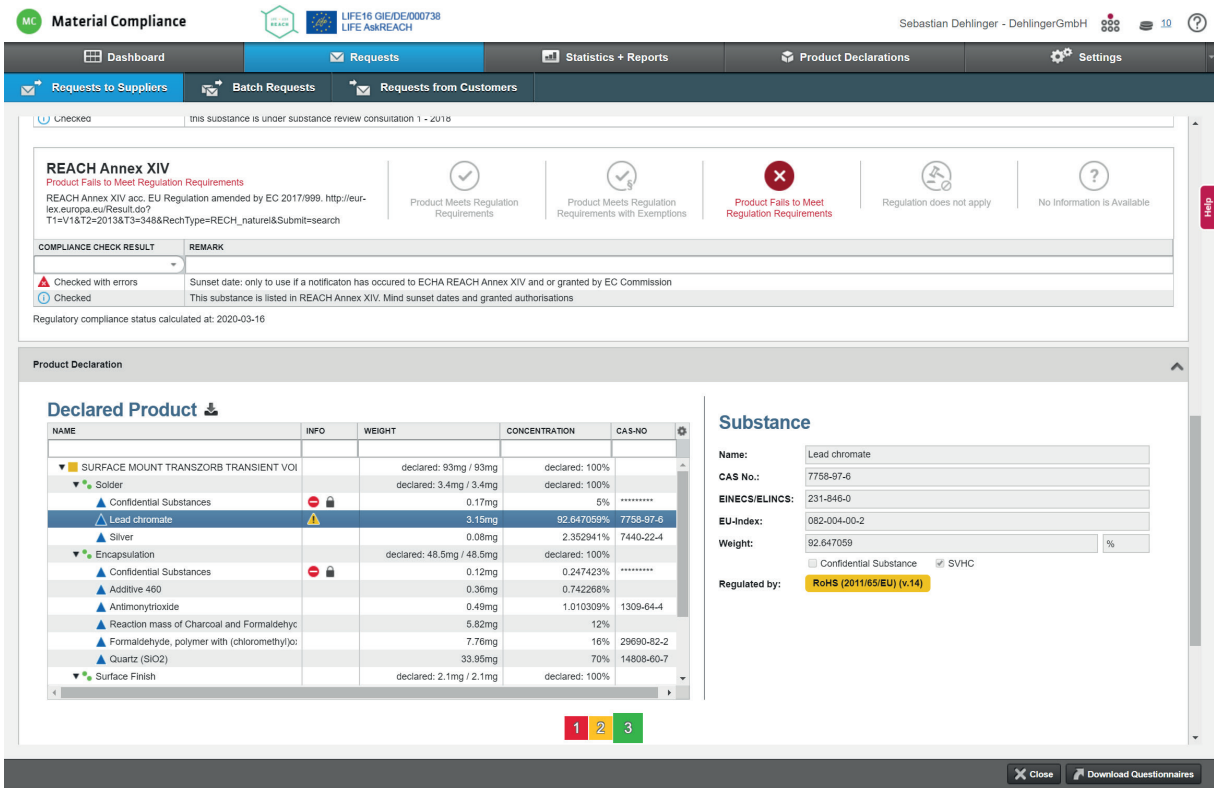

Fig. 3.5.2) Visualisation of IT tool (© iPoint-Systems GmbH 2020)

Precondition for the implementation of such a tool: The leather sector needs a collaborative approach to agree on a framework/standard accompanied by a regulation to increase efficiency.

Governance Framework:

One company alone cannot create a traceability system. Rather, this is a sector-wide effort. Ground rules are needed for the approach to be efficient and effective.

There are some organisations actively working on traceability and transparency systems that can be adopted on an industry level such as:

For example:
UN/CEFACT Sustainable Textile and Leather Traceability and Transparency Project (6) has developed a recommendation, guidelines and electronic business standards on traceability and transparency for sustainable value chains in the textile and leather sector to promote more responsible production and consumption patterns in line with the relevant Sustainable Development Goals (SDGs) of the 2030 Agenda (7).

Sustainable Leather Foundation: SLF's Pathway to a traceable and transparent leather industry
Tracing back leather to cattle farms seems to be a difficulty in the mass market . As long as there is no rule/legal obligation in place to promote traceability standards, there will be no change. And there is again the question of who bears the costs for improved traceability and, respectively, how can the farmers be supported in this matter?

Capacity Building:

The necessity and benefits of an IT tool focusing on full material declaration has been outlined above.
Notwithstanding the above, many aspects play a role and highlight how complex the overall situation is: it needs collaboration and effort to bring stakeholders from the field together, to help them achieve a mutual understanding of the problems and inspire them to find adequate industry-wide solutions, supported by a regulatory framework and standards.

Some emerging questions, among others, are:

- IT knowledge and training are needed to enter information into IT tools, especially in countries with low IT skills
- How can it be ensured that chemicals used (product names) are known by users, especially if safety data sheets are missing or are incomplete?

- Who will pay for the benefit of traceability and transparency? Companies/Brands? Consumers? Suppliers?
- Will new business models emerge where local IT services collect and progress data collected in factories?

An industry-wide approach is necessary to take steps towards better, more sustainable products.

Conclusion: How Traceability Relates to Design (Guidelines)?

Long and complex supply chains impede the ability to monitor, track and verify the leather. In such a situation, a traceability system can be helpful to design sustainable products.

More reliable information on product design

With traceability, designers have access to more reliable information to design sustainable product. Less sustainable chemicals and component parts can be identified and exchanged for more sustainable materials to e.g. achieve better performances in LCA.

Product Information

When thinking of design guidelines, it is important to consider what kind of product information should be highlighted and communicated towards consumers for trustworthy transparency.

Transparency however depends on traceability, i.e. i.e. only with IT traceability tools consumer-tailored information management regarding chemicals and sustainability is possible. Further, without traceability, it is not possible to substantiate green claims to consumers, investors and NGO´s.

New business models due to recycling enhancement

Design guidelines may create new business models also in respect of recycling possibilities. This, however, is only possible by means of traceability and transparency, as you need to know what the product contains when you are aiming to recycle or upcycle it.

Consumer awareness for sustainable leather is raising and putting pressure on brands to efficiently control their supply chains.

Designers have to consider what impacts their design will have for sustainability claims and for potential end of life aspects – either to recycle or for biodegradability. Certain treatments will make it more difficult for leather to biodegrade. Moreover, if we think of footwear, certain types of „components" will make a disassembly for re-use more difficult.

Companies not only need to design with sustainability in mind (i.e. sustainable shoes), but also need to strongly market the benefits that traceable, sustainable leather products stand for. Communication efforts of the sector need to be enhanced, highlighting the benefits that a natural sustainable leather product comprises in contrast to a shoe made of plastic, for example.

Traceability and knowing the full lifecycle flow of products from design to store, makes it possible to understand what the options from a brand perspective are; IT/ management systems are of high importance in achieving this.

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3.6
Labels and Indexes

Gerhard Nickolaus, Eva Wolf

This chapter aims at giving an overview about labels and indexes in the leather supply chain. In the course of this chapter, it will become clear to what extent labels can support design teams, taking into account the principles of Sustainable Development and which problem areas need to be addressed. The chapter does not aim to list and rate all labels being used for leather products but rather to show benefits as well as limitations for design teams.

When talking about labels and indexes, these two terms should first be defined. In the understanding of this handbook of leather design, the term "label" refers to a certificate for products or material that must meet certain (sustainability) requirements and thus represents a standard. The term "index", in contrast, means a value that can be well or poorly marked. An example of an index is the Higg Index[1].

[1] see https://apparelcoalition.org/the-higg-index/

Info box Higg Index:

The Higg Index is a set of five tools created by the non-profit organisation Sustainable Apparel Coaliton (SAC): the Higg Facility Environmental Module (FEM), Higg Facility Social & Labor Module (FSLM), and Higg Brand & Retail Module (BRM), Higg Materials Sustainability Index (MSI), and Higg Product Module (PM). By means of the Higg Index, companies can assess the performance of their products concerning social and environmental aspects (Sustainable Apparel Coalition, n. d). The lower the value of the Higg Index the more sustainable the product or material. In practice, the Higg Index is often used for the comparison between different material categories. However, Jeremy Lardeau, vice president of SAC stresses that the Higg MSI is only applicable for comparison within material categories, for organic cotton with conventional cotton (Hughes, 2021).

Worth mentioning is the current conflict about the system boundaries of the Higg Index, more precisely of the Higg MSI. Leather performs worse in terms of the Higg MSI compared to artificial leather. In 2020, several leather industry stakeholders (i.a. the International Council of Tanners – ICT) called for suspension of the Higg MSI. In a joint letter to SAC, they list several points of criticism. For example, they mention outdated datasets from 2013 that have been used for scoring leather. According to the signatories of the letter, "this is particularly

relevant to the impact of livestock rearing and the use of economic allocation to determine the environmental burden carried by hides and skins." Moreover, they criticise that the durability, longevity and reparability inherent in leather is not taken into account (Senior, 2020).

Basically, labels can be classified into B2B and B2C labels (see Fig 3.10.1.). B2B labels are important within the supply chain because they pass on specific information to producers or brands and thus can help them to comply with certain claims or regulatory requirements (e.g. REACH[2] or the proposed due diligence directive[3]). An example is the non-profit organisation Leather Working Group (LWG)[4]. The LWG developed several audit standards. One of the standards is the LWG Leather Manufacturer Audit Standard that assesses tanneries in terms of environmental impacts (Leather Working Group, n. d. a). Tanneries can be rated "gold", "silver", "bronze" or "audited" (Leather Working Group, n. d. b).

In contrast to B2B labels, B2C address consumers and are usually placed on the product or illustrated alongside products (in brochures or retails contexts) in a way that is clearly visible. They are supposed to present general statements like "this product is produced under environmentally friendly conditions" in a very simple way. Common B2C labels relevant for leather products are e.g. OEKO-TEX Leather Standard[5] or IVN Leather Label[6].

B2C labels can be divided into further categories. The first labels that existed were product-based labels and served to protect consumers. Thus, the purpose of these product-based labels was to assure consumers that the (leather) product did not contain harmful chemicals. A typical label of this type is OEKO-TEX, but also the CE[7] and GS[8] labels relevant for footwear. In the course of time and after the consumption countries and production countries have increasingly decoupled from each other, labels with a different purpose have been developed. These labels then were not product-based but production-based and covered other aspects, namely work safety, environmental protection and social conditions. The focus was no longer only on consumer protection, but also on the conditions in the supply chain of leather products. For instance, the IVN Leather Label considers all manufacturing steps within the supply chain, including social and environmental aspects (IVN, n. d.). Another example is the label "Grüner Knopf"[9], a German government-run certification label that also includes social and environmental criteria (BMZ, n. d.). Additionally, there exist labels that focus on the whole life cycle of products, even the disposal of products. With circularity aspects becoming more important – especially because of the European Green Deal and subsequent policies such as e.g. the Circular Economy Action Plan (see chapter 3.4) – the end of life of products gets more attention in society. The label "Cradle to Cradle Certified"[10] for example is a label that does not only consider social and environment aspects but also aims at enabling a circular economy (Cradle to Cradle Products Innovation Institute, n. d.).

[2] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH(

[3] see https://ec.europa.eu/info/sites/default/files/1_1_183885_prop_dir_susta_en.pdf

[4] see https://www.leatherworkinggroup.com/

[5] see https://www.oeko-tex.com/de/unsere-standards/leather-standard-by-oeko-tex?gclid=Cj0KCQjw5-WRBhCKARIsAAId9Fl9T9lDpsj-dvr2nS5HZn8qpVEhBYk-cFJfAg8Hfn6d4ekM1Z2gZU-UEaAiAwEALw_wcB

[6] see https://naturtextil.de/qualitaetszeichen/naturleder/

[7] see https://europa.eu/youreurope/business/product-requirements/labels-markings/ce-marking/index_en.htm

[8] see https://www.tuev-nord.de/de/unternehmen/zertifizierung/produktzertifizierung/konsumgueterpruefungen/gs-zeichen/

[9] see https://www.gruener-knopf.de/

[10] see https://www.c2ccertified.org/

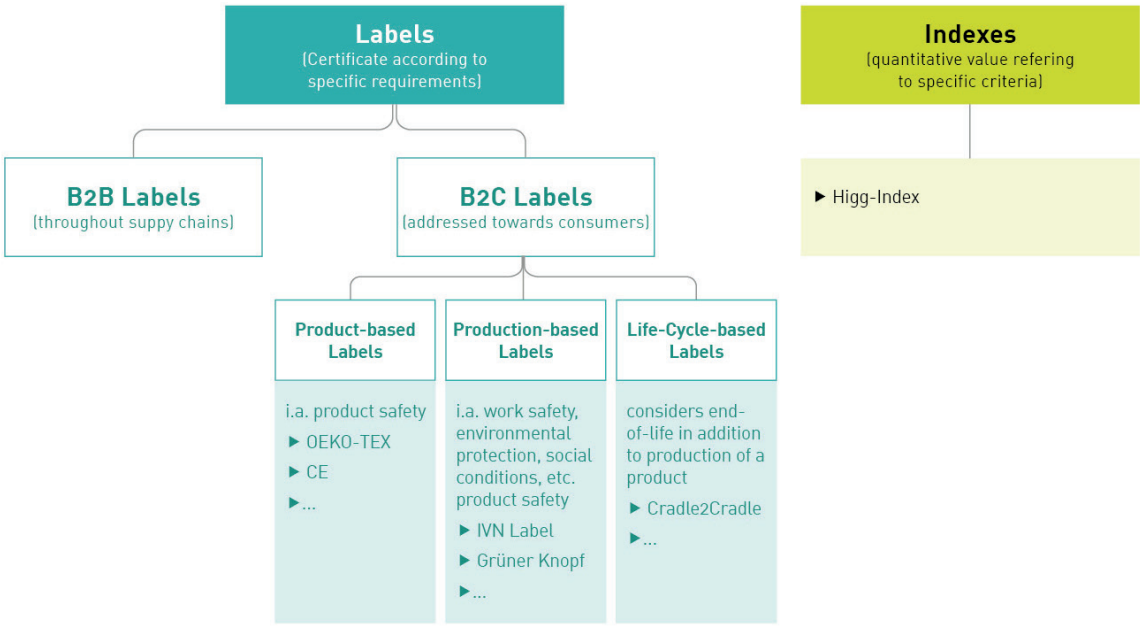

Fig. 3.6.1) Simplified Taxonomy of Labels

Moreover, labels can be divided into voluntary and mandatory labels. Most of the labels are voluntary. However, regulatory requirements and the fact that the demand for more sustainable produced goods is increasing and consumers are interested in both the social and environmental impact of their products makes labels for leather products almost indispensable. There are also a few mandatory labels, e.g. CE or GS, which are obligatory for work boots.

Another categorisation concerns the auditing. The use of labels does not end with the label itself is stuck on a product. A third party that assesses the product and verifies if it meets all requirements assigns labels. Depending on the label, auditors check these requirements batch wise (for example in case of huge quantities in discounters), once a year or every five years with annual audits. Companies must be prepared for the audits especially if certain requirements change over time.

Target Group	B2B: used within the supply chain
	B2C: addressed towards consumers
Subject Matter	Product-based
	Production-based (include occupational safety, environmental and social aspects)
	Life-cycle-based (include the whole life cycle, even the end of life ▶ CE)
Auditing	Once a year
	Every 5 years
	Batch-wise
Necessity	Voluntary
	Mandatory

Table 3.6.1) Categorisation of labels by four dimensions

As a preliminary conclusion, it can be noted that there are many labels, each with a different focus and purpose. In general, B2B labels inform stakeholders within the supply chain about specific material properties supporting producers and brands (and therefore designers) in their compliance work. B2C labels give customers information about certain impacts (health-, environmental- or social related) connected with the purchase of the product. This is intended to give them a good feeling and reduce the guilty conscience they may have due to their consumption.

Labels can support design teams by providing different guidelines for designers to follow. Depending on the label, certain sustainable criteria are then included, which can contribute to the production of a more sustainable product. For example, if a company wants to produce a more sustainable leather shoe, labels and indexes can serve as a first orientation regarding certain sustainability aspects and can even help researching and sourcing specific materials. The above-mentioned LWG label also provides a platform. Producers, brands and designers can search for LWG-certified leather manufacturers for example. So far, however, there is no label that covers all aspects of sustainable development. Design teams should be aware of this.
If a company's marketing department approaches the designers and requires them to give the product a certain label, they need to know all relevant requirements associated with it and take them into account in the design process from the very beginning. For the time being, this limits the designers in their creativity and requires them to have a very high knowledge of materials. This is challenging insofar as 40 to 50 materials are used in a single shoe. Currently, design teams and supply chains are mostly separated. However, there is the necessity to connect design teams very well with the supply chains if labels are to be used. For example, if a company wants the designers to create a chrome free shoe, they have to know where the company usually purchases the material and if chrome free material is accessible. If not they need to find other suppliers, but do these suppliers offer the same price? In addition, how can a design team assure that environmental and human rights standards are met? Moreover, the design team has to take into account that chrome freely inherited leather causes different product characteristics and affects e.g. mechanic aspects. These examples show that design teams must have extensive knowledge about materials used and need to interact with both the suppliers and different departments within the company if certain labels are used. Consequently, this means that the typical role of designers (see chapter 2.1) must change. It takes an interdisciplinary design team that brings together these different expertises and has deep insight into the whole supply chain, which is changing more and more often due to shorter fashion cycles. Such a new design team is no longer concerned only with artistic aspects, but above all with technical matters that must already be taught and strengthened during education.

Using labels and indexes creates orientation with regard to different sustainability aspects. Design teams and their companies do not need to make up their own rules for a sustainable leather product but can take advantage of existing labels and indexes. However, if companies create their

own sustainability criteria, labels and indexes can be a source of inspiration. Notably B2C labels serve as a marketing instrument by showing the product's sustainable performance to the customer at a glance. However, (B2C) labels only contribute to more sustainable products if customers accept the label and are willing to pay a higher price. Only when the demand for more sustainable products reaches the general population (and this is currently happening) will labels gain in importance.

It is also noteworthy that not all labels have the same validity and differ greatly from each other. Hence, it is important that design teams always have a closer look at each and every label and index and scrutinise the related criteria. This also includes learning about audits. Design teams should keep in mind what criteria an audit will review and whether it will be announced or unannounced. This of course influences the reliability of labels and indexes. In the textile industry, it can be assumed that certain suppliers use special fabric samples for audits that meet the respective sustainability requirements. However, the final garments often contain completely different and often problematic substances that harm people and the environment (Wolf, 2022). It remains questionable whether this is also the case with leather audits that are at least structurally very comparable. To sum up, labels and indexes should not be understood as a simple declaration that a certain (leather) product or material is more sustainable, but rather as an assistance to design teams, which at the same time requires extensive supply chain knowledge and is sometimes accompanied by obstacles.

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3.7
The History and Culture of Leather

Inge Specht

The Discovery of Leather Tanning; a Milestone in Human History

The history of leather preparation and tanning is a long and very interesting one. The exact starting point of tanning is hard to tell, but it must have been sometime between 10,000 and 4,000 BCE. Throughout the Upper Paleolithic period (40,000-10,000 BCE) hides were used to protect people from sun, cold or rain. It is plausible that hides at that time were protected from immediate decay by treating them with smoke or salt; techniques that may have been discovered accidentally. Unfortunately, the effect of this kind of preservation only lasted until the next rain shower. The next step in discovering the secret of tanning occurred thousands of years later. During the Neolithic period (9,500 BCE- 5,500 BCE) people started to use marrow, brains, organs and fat (or a combination of these animal ingredients with smoke and/or salt) to preserve hides.[1] The hides were used to make clothes, shoes, tents and blankets. Bones, horns and other inedible remains of the animal were transformed into tools or decorations. Because of the effort people had to put into hunting, every bit of the animal was used.

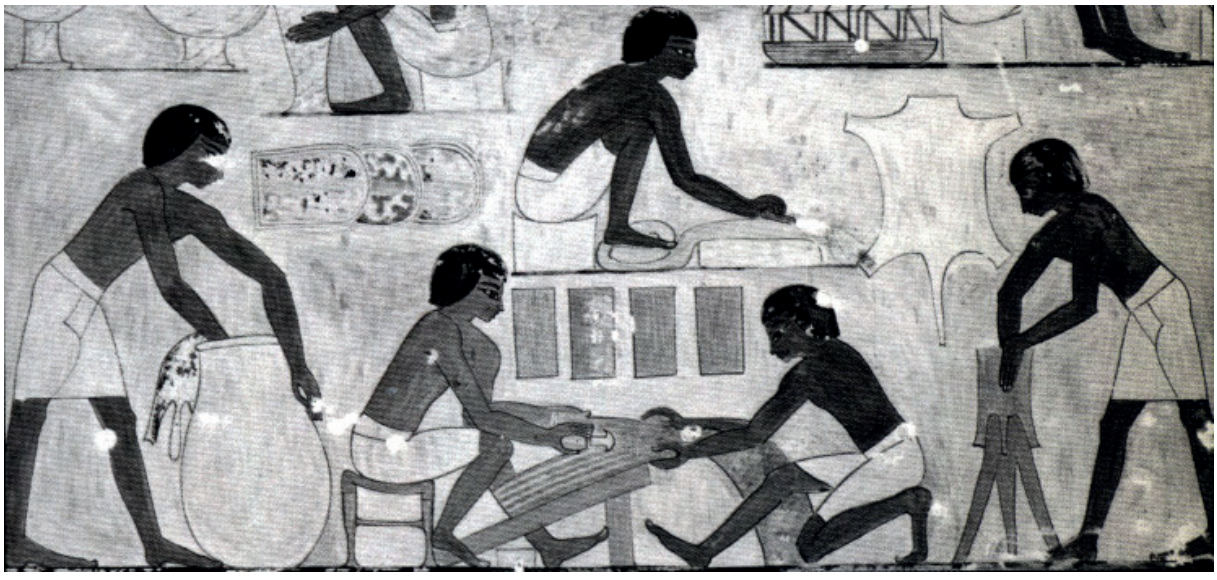

Fig. 3.7.1) Leather Workers, Tomb of Rekhmir, ca. 1504–1425 B.C. Rogers Fund, 1935 (Public domain)

The tanning process as we know it today, i.e. the preservation of the skin through the use of tannins, originated around 6,000 BCE in areas such as Egypt, China and Mesopotamia (e.g. fig. 3.7.1). The people who lived in these areas, such as the Sumerians, already appreciated the tanning effects of aldehydes, essential oils and galls at an early stage. Perfection of leather tanning techniques, however, was achieved by the Babylonians, the Egyptians and the Persians. The Egyptians, for example, mastered oil-based tanning as well as mineral and vegetable tanning techniques. These techniques would not have been discovered if leather's unique combination of qualities had not been recognised. Firstly, the different qualities of the available tannins in the direct living environment of the tanners had to be determined; no doubt one started experimenting with locally available ingredients originating from plants and trees, but also with waste products such as urine and pigeon droppings.

The development of leather and leather products kept pace with the great appreciation for materials and craftsmanship. The latter was in stark contrast to the work performed by tanners. In most societies, the tanning profession was seen as inferior and as such the tanner belonged to the lower layers of society. Working with dead animals, the smell of decomposition and the risk of contamination with deadly bacteria were the basis for this. In India, tanners belonged to the group of casteless or untouchables: even walking in their footsteps was said to cause disaster.

Tanneries were always located on the outskirts of a city to limit odor nuisance. After the leather had been tanned, the leather worker or shoemaker could get to work. Depending on their skills, their work was better appreciated, but rarely well paid. The group of wealthy people that could afford luxury goods was relatively small and everyday utensils were therefore not quickly replaced but endlessly repaired.

The high cost of materials encouraged sustainability. A purpose of use was devised for each part of the animal. Meat, fat, organs, blood and marrow were used for consumption. Hair was used for making brushes or as a filling for furniture and saddles. Bones could serve as raw material for glue, tools or be made into ornaments or even a sledge. Clothing and shoes were repaired for as long as possible before finally being replaced. Shoes, worn beyond repair, were cut up and reused for the repair of other shoes. Discarded utensils were first stripped of usable parts or finally used as firewood.

One of the reasons materials used to be so precious was that it took a lot of effort to acquire them. Materials were made and/or processed manually, therefore the supply remained smaller than the demand. Exotic raw materials, such as tropical woods, silks and spices, had to come from afar and trade trips took a long time and were not without risks. Long processing times also applied to leather tanning. Depending on the thickness of the skin and the purpose of use, the tanning process took at least nine months. The tanning of sole leather, for instance, even took one and a half to two years.

Historical References for the Use of Leather

Until the end of the nineteenth century, most leather was tanned with vegetable tannins. With the increasing knowledge about tannins and tanning processes, a greater variety of end products emerged over the centuries; thin, supple leather for the uppers of shoes; thick, water-repellent sole leather; sturdy leather for belts, bags and knife holders; heavy, extra-thick leather for shields, breastplates, cuirasses, upholstery and even bottles for the storage of oils and spirits. The list of applications turned out to be virtually inexhaustible. In fact, one could even say that leather was the most versatile material before it was supplanted by plastics in the twentieth century.

Fig. 3.7.2) Sandal made of raw hide, Africa 20th century, collection Schoenenkwartier, invnr. 11424

By combining the different types of leather, the number of applications multiplied in which the properties of the leather could be optimally utilized. For example, it enabled the Romans to produce shoes made from one piece of sturdy leather (the carbatinae) as well as openwork boots (the caligae) whose upper was made of supple leather and whose outsole was made of specially tanned bovine or ox leather. This is more or less how shoes are still made two thousand years later.

Intriguing Leather Processing Techniques

Until the invention of synthetic glues, leather products were made by sewing the different parts together. The objects were embellished with paint, engraving, embroidery or decorated with (precious) metals. It is beyond the scope of this chapter to discuss all these techniques here. Nevertheless, the author would like to draw attention to two special techniques, mainly because they have been rediscovered recently by a number of contemporary designers.

Cuir bouilli and wet moulding

Fig. 3.7.3)
'Fendi mannequin', made with cuir bouilli technique, Simon Hassan, UK, 2013. Courtesy of Simon Hasan.

A very interesting application of leather is known by the name cuir bouilli. Cuir bouilli is an old Norman term for a technique that processes wet leather using a mould. It was used for the manufacture of drinking vessels, bottles, boots, helmets, cuirasses and shields, among other things. Cuir bouilli literally means 'cooked leather'. For centuries that term has caused a lot of confusion as leather loses its firmness completely when heated to around 75-90 C° and after drying it becomes dry and brittle. [2] So in fact the leather is not boiled, but heated in hot water until the shrinkage temperature of the leather is reached. This limits the leather's loss of elasticity and creates a stiff, strong material that can be used to manufacture both water resistant and protective objects like containers and buckets. To maintain its shape, the leather still needs to be finished. A disadvantage of cuir bouilli is that it eventually may dry out and become brittle. A technique that leads to a more stable result is known as wet-formed leather. The leather is soaked in water for a few days and then pulled over a mould and dried. Optionally, separately manufactured parts are sewn together, as is the case with miners' helmets. Wet-moulded or formed leather is very strong and stable.

It is not unimportant to mention that this technique can only be applied on vegetable tanned leather. Vegetable tanned leather, due to its tanning method, is less waterproof than Chrome-tanned leather and is prone to uptake water more easily. Contemporary examples of cuir bouilli can be found in designs by Simon Hasan, Sanna Svedestedt and Christoph Lemaire, but also in the haute couture collections of Alexander McQueen, Schiaparelli and Marina Hoermanseder. The Shoe Museum will be hosting an exhibition on this extraordinary material by the name 'The magic of cuir bouilli' in Spring/Summer 2023.

Fig. 3.7.4)
Sixteenth century shoe made into a mule.
Collection Schoenenkwartier, Invnr. 12088

Wet moulding is reflected in the traditional footwear of the Balkan peoples, the opanci. The sole of this shoe type is wet-moulded around the bottom of a shoe last, creating a waterproof sole with raised edges. The upper is then braided from strips of leather. Dutch shoe designer Amber Ambrose Aurèle

has created a small collection of high heeled shoes inspired by Serbian opanci, using the raised edges as a specific feature of her designs.

Fig. 3.7.5] Rex Lingwood, Bowl, 1990s, cuir bouilli technique, collection Schoenenkwartier Invnr. 85065,

Gilt leather

Another product in which moisture and temperature played a major role during production was gilt leather. Gilt leather was used as a wall covering and replaced the woven tapestries that had insulated the walls of palaces and castles for centuries. Gilt leather was produced in Ghadames, Libya, as early as the ninth century. Via the Umayyad conquest of Hispania, the technique also reached the Iberian peninsula from where it spread to Italy and northern European countries such as the Netherlands and England. Manufacturing gilt leather was a very time-consuming and specialist-type of work that also required a great deal of material knowledge.

Gilt leather was made by covering wooden frames with bovine leather. After stretching, the leather was covered with silver leaf. This could only be done in dry weather, as silver corrodes immediately and turns black in a damp environment. Subsequently, the silver leaf was covered with a yellow varnish, creating a golden shine, after which gilt leather is named. Once the vanish had

dried, the leather could be embossed by pressing a pattern into the leather using moist at a mild temperature. The gilt leather then would be finished by painting the front of the panel and by varnishing it again. After all these time-consuming steps the gilt leather could finally be used to produce wall coverings, upholstery, folding screens, luxury boxes or writing tables.

Fig. 3.7.6) Fragment of a gilt leather wall hanging, Southern Netherlands (Belgium), 1675, Collection Schoenenkwartier, Invnr. 93108

Gilt leather remained popular as a wall covering well into the eighteenth century, after which it was replaced by wallpaper. The material also fell into oblivion for luxury items; only a few craftsmen would venture into the time-consuming process. Fortunately, leather has recently been revisited as a wall covering and even a floor covering. This time, however, in its natural splendour. The Shoe Museum has a very interesting collection of gilt leather fragments from the early sixteenth century to the early twentieth century.

Contemporary Use of Leather

The Industrial Revolution marked a turning point in the production of leather and thus also in the production of leather goods. The invention of the tanning drum accelerated the tanning process from a few years to a few dozen hours. It meant that leather became cheaper and accessible to a much larger group of buyers. The luxurious image remained, partly due to the arrival of chrome tanning, that infinitely increased the number of finishing options. Nevertheless, over the next century, leather increasingly lost ground to synthetic materials that were new and therefore fashionable. In addition, the image of leather was damaged by the environmental impact of large-scale tanning – long before the discussion about the environmental impact of plastics. Despite the negative connotation that leather evokes in some, it is still a widely used material in several industries of which the shoe and luxury leather goods industries are probably the best known. At least as important is the application of leather in the automotive industry and for interior design. These industries take full advantage of the unrivaled properties of this natural material.

Automotive

In the automotive industry, leather is mainly used for upholstery. Car upholstery must meet a large number of requirements. For example, it is important that the surface of the leather does not feel too hot or too cold for the car user. It also has to be durable, breathable and it should not melt in case of fire. Many luxury car manufacturers still opt for leather, which meet all these requirements while having a luxurious appearance.

The use of leather in vehicles is already known from ancient Egyptian chariots. In 2008 an almost complete leather casing of a wooden chariot was discovered in the Egyptian Museum in Cairo.[3] Leather can also be found on carriages from the eighteenth and nineteenth centuries. On all these vehicles the material is usually found on the outside, for example on the panels or in the hood. In this case, the leather was probably used not only to enhance the appearance of the carriage but also to protect the wood from rain.

Interior design

When talking about the use of leather in interior design, the first things that probably come to mind are leather upholstered sofas and chairs. However, those who remember the gilt leather mentioned earlier in this chapter will not be surprised to learn that leather offers many more possibilities in interior design. As in the heyday of gilt leather, contemporary smooth or printed leather tiles are a luxury option for cladding walls, doors and fireplaces. Absolutely new is the application of leather on floors and stairs as well as in kitchens and bathrooms.

Historical Value and Connotations as a Design Resource

There is hardly any material that is currently still used, that has such a long and diverse history as leather. With regards to sustainable development, design teams are advised to regard this as a design asset that can increase emotional attachment and willingness to care for a product (see also chapter 3.8).

While some current trends seem to focus on hightech material finishes that create homogeneous and unchanging surfaces, embracing the natural characteristics and the aging patina of this material might refer to its historical usage and its durability across time. However, it is the design team's challenge to make use of this resource in contemporary design concepts that fit the needs and demands of consumers and markets.

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[4] It is important to note that the word ‚leather' within a brand name for vegan materials is misleading. The word ‚leather' basically refers to tanned animal skins. The leather industry, therefore, is striving to ban the use of the word leather as a designation for leather substitutes, which has already been achieved in a number of countries.

3.8
Consumer Behaviour and Leather

Ann-Cathrin Jöst, Andreas Meyer, Jonas Rehn-Groenendijk, Charis Eisen

Solomon, Russell-Bennett and Previte (2012) refer to the American Marketing Association when they describe consumer behaviour as "the study of the process when individuals or groups select, purchase, use or dispose of products, services, ideas or experiences to satisfy needs and desires". Consumer behaviour in relation to Sustainable Development builds on a similar notion as "actions that result in decreases in adverse environmental impacts as well as decreased utilization of natural resources across the lifecycle of the product, behavior, or service." (White, Habib and Hardisty, 2019).

In many countries, consumers have become more and more aware of environmental consequences of the products they buy. An increasing number of people, so called eco-friendly consumers, put pressure on governments and corporations to pay more attention to environmental consequences of economies by demanding eco-friendly products (Cohen, 2015; Nielsen, 2018). Who are these eco-friendly consumers? Research has shown that women are more environmentally concerned than men (e.g., Laroche et al., 2001; Fisher, 2012). This can lead to more environmentally friendly product choices, but factors other than gender play a crucial role, such as price and appearance of a product. Further, people with higher formal education and with higher incomes are in general more likely to buy eco-friendly products (e.g., Nielsen, 2018). However, as people with high incomes consume a lot, they have the highest environmental footprint. Moreover, those working from home were found to shop more sustainably and age-wise, it is generation Y and Z who considers environmental aspects the most in their purchase decisions (PwC, 2021). Importantly, these demographic and socio-economic variables are not as influential as psychological and behavioural variables, such as knowledge, values, and attitudes (van Bergen, 2016). These findings stem all from Western countries, and consumers'expectations and habits vary greatly from country to country. Therefore, when thinking about one's target group, it is important to check characteristics of eco-friendly consumers in the region of interest.

Brands and retailers of environmentally friendly products commonly do not want to limit their target group to eco-friendly consumers but try to motivate people to adopt more sustainable consumption behaviours. This is undermined by various challenges though. Consumers who are adjusted to buying specific products or to specific consumption behaviours may not want to adapt, as

changes could threaten their identity that has been formed around these specific behaviours and products. Following the concept of reactance (Brehm, 1966), a feeling of limitation or decreased freedom of choice could result in even more unwanted consumption patterns. Moreover, when the same consumption behaviour is performed regularly, it is often no longer a conscious choice but has turned into a habit, which is difficult to change (Verplanken, 2006). If a change of habit is intended, making the desired change as easy and effortless as possible seems to increase chances (Diekmann & Preisendörfer, 2003). To promote more sustainable consumption behaviour, it is important to connect the intended behaviour to a sustainability goal that the consumer can connect to. Research found that consumers are less likely to buy a certain product if a sustainability goal such as "stopping climate change" is very difficult to achieve instantly, or if the sustainability benefits are disproportionate to the challenges faced by the consumer in the immediate proximity (e.g., White et al., 2019). In addition, behaviour is more likely to change towards sustainable behaviour if the consumer feels emotionally attached to the product, perceives that the purchase has a direct positive impact and if the product is (financially) accessible to the consumer (ib.).

For the design of leather products (and for that matter for most other products), this means that sustainable buying behaviour can be influenced or encouraged by putting an emphasis on integrating product knowledge or sustainability values into the design. At the same time, design should take into consideration an interplay of different aspects. To do so, it might be very useful to think about the target group using personas, i.e., prototypes for a group of users with concrete attitudes and behaviours. These fictional characters can be created based upon market research to represent the different user types that might use the product in a similar way. Creating personas helps to understand users' needs, experiences, behaviors and goals and thus, personas help to design products and product information in such a way that users will like it (Cooper, 1999; Chang, Lim & Stolterman, 2008).

In the following, we distinguish three consumer behaviour aspects - (1.) purchasing behaviour, (2.) using and maintenance of products, and (3.) disposal and reusing - and shortly outline (4.) societal development and consumer behaviour beyond and parallel to product interaction.

Purchasing Behaviour

From an industry point of view, purchasing behaviour may appear to be the most interesting aspect, as it has been the subject of research for many decades (e.g. Packards seminal book from 1957). The major question in this context is when, why, and how a consumer buys or does not buy a certain product or service. The following three steps are a rough simplification of potential purchasing motives apart from spontaneous impulse purchases.

1. The primary buying thought: Type of product rather than material

When a consumer decides to purchase a product, the consumer is often aware of the type of desired product in advance. However, in most cases, consumers do not choose leather but choose a leather shoe, a leather sofa, a car with leather seats, or even just a shoe, a car, or a sofa. Needless to say, this categorical thinking also relates to branded products such as an iPhone or a Mercedes. Therefore, the consumers' need for a specific product can be a starting point for any design and communications effort.

2. Consumers second thought: Material choice

In a second step, after the need for e.g., a new pair of shoes is clear, the consumer may think about specific attributes such as the price, style, or material, i.e. leather or an alternative to leather. However, this is not mandatory. In other cases, the purchasing behaviour occurs incidentally when going to a store or finding out about an offer on the internet. At this point, subtle marketing strategies can exert powerful effects (e.g. Lindström, 2010).

Taking shoes as an example, leather as a material could already be a consumer's priority when selecting potentially interesting products (A consumer might think: "A men's dress shoe must be made of genuine leather."). In addition, drivers for purchase can be fashion, price, brand loyalty, etc. However, considering aspects of sustainability (e.g. origin of the material, circular business models, environmental impact due to chemicals used during products) requires respective knowledge.

3. Sustainable design to encourage sustainable buying behaviour

More critical and informed consumers have the potential to influence the leather supply chain through their behaviour. Consumers interested in getting more information about the leather from which the shoe is made do not find it easy to get information nowadays: While knowledge is a central prerequisite for environmentally conscious behaviour (e.g., Roubanis, 2008), the UN has noticed that consumers are insufficiently informed and urged to take steps to correct this situation (UNIDO, 2010). However, there have not been many informational campaigns or media attention since. Consequently, a recent study in Germany found that even in a highly educated sample, most participants' knowledge about leather products and their manufacturing was limited (Eisen et al., under review).

Consumers interested in getting more information about the leather from which the shoe is made do not find it easy to get information: Where are the hides from, where were they tanned, what was the situation for the people who tanned the leather and produced the shoe, which chemicals were used? Most brands do not offer this kind of information[1]. Since conscious consumers would

[1] see for more information on regulatory requirements and approaches for tracing and communicating information see chapters (3.4; 3.5 and 4.5)

need to do intensive research before considering buying a shoe from a certain brand, they may decide on those brands that offer the needed information. For example, some brands such as Meindle already offer (QR) codes with their products allowing consumers to find more detailed information about materials and origins. Another way to decide on a product with limited information is to trust in labels, where available. Labels are in many cases the only information consumers get on the sustainable performance of a product. Although it is very hard to know all relevant labels and the criteria to be met, many people trust in products of brands with concise messaging on climate impact and third-party certification (UK Leather, 2021).

1.4 Willingness to pay

Studies have found environmentally aware consumers to have generally a higher willingness to pay for products that are produced in environmentally less harmful ways (Tey, Brindal, & Dibba, 2018; Ha-Brookshire & Norum, 2011). Assuming that the leather industry would be less hesitant to invest in manufacturing of leather products that are less harmful to environment and tracing systems for chemicals if this investment could be compensated for by retail prices, Eisen et al. investigated consumers' willingness to pay. They found that consumers are willing to pay more for leather products that have been manufactured in a way that is less harmful to environment and health and an additional premium if information concerning the supply chain is provided. These findings indicate that some of the extra costs that may accrue for measures to promote sustainable development can be forwarded to consumers, if plausible and well-communicated.

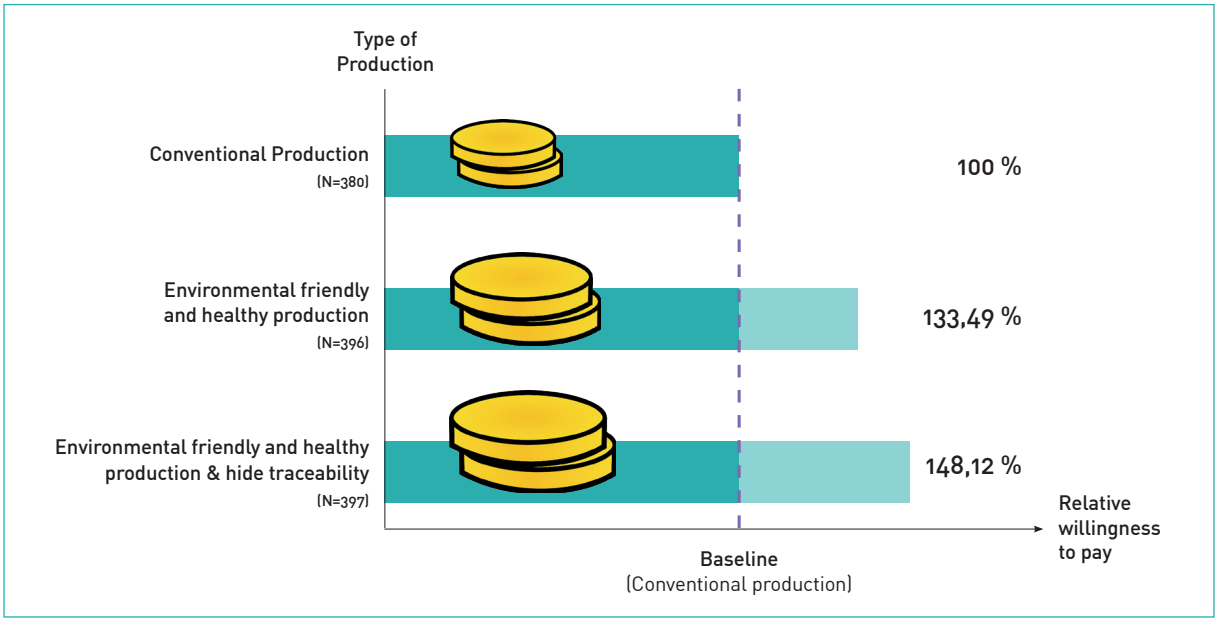

Fig. 3.8.1) Adapted illustration of the results of the investigations by Eisen et al. (under review; 2022)

1.5 Irrationality of purchasing behaviour

In line with current research findings in the field of consumer psychology (e.g. Dijksterhuis et al., 2005), neuro-marketing, and behavioural economics (Ariely,

2010), purchasing behaviour is complex and in many cases based on situational and often subconscious aspects. Price, status, and seasonal trends affect this in the same way as association with specific memories, peers, and symbolic values (e.g. Lindström, 2010, 2011). An important aspect of purchasing and using leather products is the meaning and signs these products represent. Products can be seen as signifiers to enable consumers to be part of a group (e.g. Harley Davidson or Apple) and indicate shared values or beliefs. Designing products and business models with this in mind can create a strong emotional bond and strengthen the willingness to maintain and keep products rather than disposing of them to buy the latest seasonal fashion.

Design teams that aim at creating products that foster sustainable development are advised to not only consider the factual and rational impulse of consumers when making purchase decisions. In coordination with marketing and communication efforts (see also chapter 4.5), design decisions must be based on comprehensive strategies that follow specific principles and aim at certain effects. This can serve to raise awareness of environmental and health concerns associated with conventional products. Examples of this can be found in the field of organic food, which in many cases is advertised and presented as the healthier and more environmentally friendlier choice. However, marketing and design strategies can also focus on aspects of sustainable development as a self-evident mindset following the overall DNA of a brand. Several children's toy brands follow this principle. Instead of primarily communicating their sustainability efforts, it is part of their image of being fair, future-oriented, and social.

Furthermore, as many purchasing decisions are largely determined by product prices, innovative and sustainable business models could be a tool to target a new audience by using, for instance, leasing models (use-oriented product-service-systems). Instead of buying an expensive shoe at a high price, consumers can choose to wear this shoe for a certain period at a significantly lower price. In this case, a circular business model is not the actual reason for the purchase, but the need for a lower price, which in turn triggers the impulse to buy.

Using and Maintenance

Apart from the actual purchase behaviour, consumer behaviour also refers to how consumers interact with these products, how long they are willing to use them, how well they treat and maintain these products and whether or not they will reuse leather products (see also Ceschin & Gaziulusoy, 2016).

In contrast to many other materials (such as polyurethane), if applied properly, leather is very robust, repairable, and can last for decades. This allows leather products to have an extended lifetime and to be reused by other consumers. This potential of leather is further supported by its cultural and emotional value (see e.g. chapter 3.7), which is usually associated with luxurious and durable materials. However, recent research shows that only a few people repair their broken leather products or bring them to a repair service (Leather UK, 2021).

The best way to improve maintenance behaviour is to get users involved. For consumers to keep a product for a longer period of time or to even pass it on to another consumer (e.g. a father giving his son his old leather wallet), an emotional bond between consumer and product is required. This emotional product attachment, the „emotional bond a consumer experiences with his or her product" (Schifferstein & Zwartkruis-Pelgrim, 2008), leads to retention and maintenance of products, which extends the product's lifespan (Mugge et al., 2006). Emotional product attachment has four dimensions (Mugge et al., 2006; Tlhabano et al., 2013): self-expression, group affiliation, memories, and pleasure. Hence, new design innovation should strive to incorporate elements of emotional attachment by designing products that boost user identity through personality enhancement and social recognition, and encourage playfulness and memorable product experience without comprising on the functionality and utility of products. From an aesthetic point of view, using styles that are more generic and less extravagant can create products that are fashionable beyond one season and timeless, which in turn can be used as a marketing strategy (chapter 5.1).

In addition to designing products so that they encourage long usage and maintanance behaviour, offering product ecosystems and marketing strategies might also strengthen maintenance efforts. In contrast to "fast fashion", leather products have the potential to emphasise long-lasting relationships between product and consumer, creating new business opportunities (e.g. in form of product-service-systems). Still, consumer knowledge is key for extended product lifetime. Consumers need to be aware of the potential lifetime of a product and know how to maintain and care for products (including services and care products). This applies to material knowledge as well. If consumers are able to differentiate between different levels of quality and acknowledge higher prices for more durable products, both purchasing and maintenance behaviour can change in favour of sustainable development (see chapter 4.5 on aspects of marketing and communication that can support this process).

With regard to sustainable development, extending product lifetime and offering services and products to support this must always be evaluated from a systemic point of view. Only if care products and maintenance services fulfill ecological standards and do not harm humans and the environment, the extended product lifetime can be regarded as more sustainable. Unfortunately, many products and services that aim at repairing or protecting leather products contain chemicals that can be described as potentially harmful to both humans and the environment. Consumers are in many cases not aware of this: A recent study found that 60% of participants who buy leather protection products do not check chemical ingredients (Eisen et al., under review).

Disposal & Reusing

As opposed to consumables, the disposal of products such as leather jackets can be less straightforward. While many countries separate waste (e.g.

paper packaging) to facilitate recycling, consumers have various options for disposing of old leather products. Increasingly, the authors are seeing joined projects between leather manufacturers, chemical companies, and brands resulting in newly developed leathers that can be composted, like the Re-suede of Puma.

With the rise of online second-hand platforms (e.g. eBay, Vinted) and sharing trends, many consumers are becoming more conscious of the potential second life of their products. This applies in particular to the case of leather products due to their high repairability and reusability. However, this disposal behaviour depends on a number of aspects. Firstly, the leather product needs to be durable and of a quality that justifies the efforts and costs of selling and reusing a product. Needless to say, this is mainly defined by the design of the product (see Chapters 4.1 and 4.2). Secondly, consumers need to know that the products can be repaired, refurbished, and reused. This is closely related to the image and associations connected to leather as a material and the product at hand. For instance, many luxury brands market their leather products not only as high-value and fashionable items but also in a subtle way as investments. Thirdly, services and systems need to be available for users to easily sell or pass on these products for reuse. While in many cases charity organisations and second-hand businesses offer sophisticated services, brands and retailers still lack appropriate systems (see also chapter 4.4 for the notion of circular business models).

Societal Development and Consumer Behaviour beyond and parallel to Product nteraction

In a broader sense, consumption and production patterns are subject to social and industrial trends. For several decades, the trend toward fast fashion has also affected the way leather products are offered. While in the 20th century and before, leather was a luxurious material to be kept and passed on, today it can be found in discount fashion stores all over the world. While leather is still associated with luxury (e.g. car interior design), its overall image has become blurred, including consumers' knowledge of leather quality and care.

In line with concerns about animal welfare, harmful substances, and social inequality in countries of production, many consumers are uncertain about the extent to which leather products can be sustainable. As this handbook emphasises, leather products are not sustainable by default, but rather need to be designed and marketed in a specific way to support sustainable development. As with many other product categories, only informed consumers can purchase, use and dispose of products more sustainably. In the case of leather, stakeholders such as brands are advised to stimulate informational behaviour, emphasise the valorisation of leather products and leather as a material, and improve knowledge about the care and quality of this material.

FOCUS: Sustainability as a question of ability and will: A plea for the inclusion of education in development strategies

Heike Hackmann

What makes a sustainable product? Which criteria are decisive? What are the consequences of more or less sustainably manufactured products for the environment and people? What possibilities do I have as a consumer, as a citizen, as an employee of a leather processing company to influence the production conditions? Where do I get the necessary information to make a good decision?

These are not the only questions raised in these guidelines. They should also be addressed in a fact-based and comprehensive manner by the general public. Because only if as many people as possible in different functions and positions can fill the concept of sustainable development with meaning and apply it to themselves can such development succeed. Education plays a central role in this.

Anyone serious about sustainability will not be able to avoid incorporating impulses into education and from education into his/her strategies.

The focus here is on various phases in an educational biography: general school education, consumer education, vocational education and higher education.

In school, the topic of responsible consumption can be dealt with using the example of leather, shoes or leather goods. The guiding questions are comparable to other product groups and can be transferred. This critical-constructive discussion must take place at all in school lessons. Unfortunately, this does not yet happen all that often.

However, consumer education should not be directed solely at young people as a target group. Using other methods, adult consumers can also benefit from a more comprehensive knowledge of sustainable product quality. If they choose durable goods that are produced in an ecologically and socially compatible way, everyone benefits.

Competent consumers need equally competent contact persons in the economy as counterparts. Professionals in leather production are also required to expand their knowledge and skills in the direction of sustainability. This applies to farmers as well as to chemical experts, process technicians, leather processing craftsmen and craftswomen and last but not least the sales personnel at the point of sale. The players in the industry must be able and willing to produce sustainable materials such as leather, process them into attractive products and explain them to customers.

If both sides, the suppliers and the consumers, want to face up to their responsibility and make their contribution to a healthier and fairer world through good products, sustainable business has a good chance of succeeding.

The leather industry should support such educational activities through a transparent information policy and sustainable product offerings and services.

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3.9
Product Ecosystems in the Context of Leather

Jonas Rehn-Groenendijk

As with most consumer products, leather products are not only embedded in long and complex supply chains, but also connected to a number of other products and services. A typical example of this is the men's dress shoe for which several types of care products are available. A shoe tree is usually used to store the shoe. Sometimes shoes are stored in a cotton bag, on specific shoe racks or in shoe boxes. In case of scratches or worn out soles, shoemakers offer a wide range of services to maintain the product. In higher priced segments, shoemakers may even dismantle the shoe on a regular basis, about once a year for example, to "refresh" it. And although less common these days, the role of shoeshiners as specialists in the quick polishing of dress shoes resembles the social symbol of the shoe in the business world.

These networks of products, services, business models, individuals, roles and many more that surround a specific product like a leather shoe are called product ecosystems. From a systemic point of view, the respective ecosystem should always be taken into account when designing more sustainable leather products. Firstly, by considering product ecosystems, potential rebound effects can be more easily identified. For instance, if a shoe is provided with a coating that is more sustainable due to the absence of harmful additives, but requires more care by customers, this can lead to a higher usage of environmentally harmful substances contained in care products.

Secondly, product ecosystems can be a valuable starting point for analysis and ideation, as new business models and product-service-systems can be designed if existing ecosystems are better understood. Customers may be willing to pay a higher price for a more sustainable leather jacket and feel more attached to it if the retailer offers special care packages or the like (e.g. on a flat rate basis). This not only underlines the genuine value of the product and the material, but also strengthens customer loyalty if it is communicated and designed properly.

How to Identify the Product Ecosystem

Usually, there is no single product that is not to some extent embedded in an ecosystem. From a systems' theory point of view, a system is a conceptual framework that helps to structure the real world by using a more abstract model of it. Even though every element in the physical and digital world is somehow related to another, we can draw artificial boundaries to focus on specific aspects or topics.

For this purpose, systemic maps are a good tool to visualise systems (e.g. in form of a mindmap). In the case of leather products, categories such as products, services, professions, business models and locations could be a good starting point. From there, one could differentiate the product category in elements such as care products, storage products etc. Once an ecosystem map is created, the most interesting part is to identify existing and potential links, relations and interdependencies. For instance, professions such as shoemakers depend on a certain level of quality in leather products to provide their services properly and may face significant challenges when being confronted with cheap fast-fashion leather products.

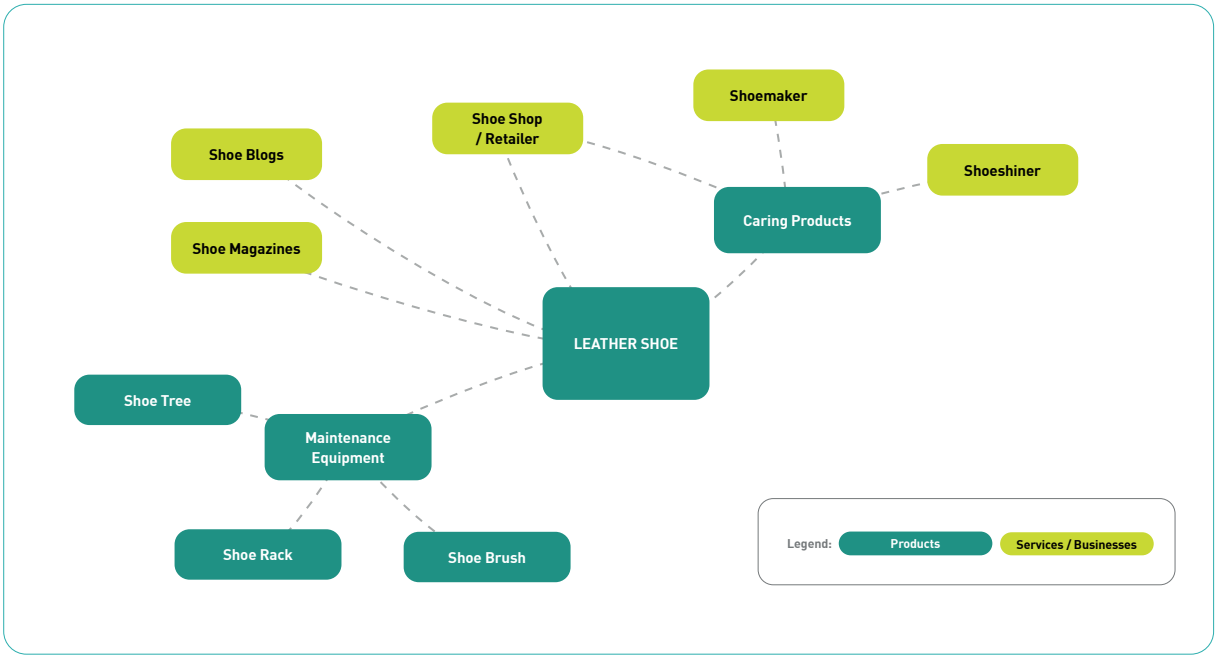

Fig. 3.9.1 Visualisation of a simplified product ecosystem for a leather shoe

Different Roles and Types of Relationships

When having a closer look at the context of a product, one may find a variety of roles and interdependencies that occur in these systems. Although the amount of categories and the degree of magnification depends on the product context and scope of a project, a helpful starting point could be to consider the following aspects:

At a very superficial level, a distinction can be made between products and services found in the context of a product (see Fig. 3.9.1). Relationships can be identified not only between the product of interest (e.g. the leather shoe) and other products and services, but also between these other elements illustrating potential synergies.

At a more detailed level, the type of relationship can be of interest. Do some products or services depend on others? Do they form synergies when delivering a certain offering?

Based on this, the element of time can provide further insights. With regard to sustainable development, this applies in particular to the notion of production phase vs. use-phase vs. end-of-product-life phase. However, considering the chronology of a specific product in the context of mapping ecosystems should not aim to visualize the entire supply chain. While this can be a helpful tool to understand other issues of sustainable development regarding this product, the key idea of a product ecosystem map is to illustrate all elements directly related to this product based on its use case. With this in mind, a time-wise perspective should focus on developments that are closely related to the product (e.g. Where to purchase or receive the product? Where and how to give it back? Are there additional services that facilitate these phases?

A product ecosystem map can be used not only as an analysis tool, but also to generate ideas for potential collaborations or innovations by creating a map of the future state ecosystem.

Other Useful Types of Ecosystems

In addition to this, one can also analyse the context of a product using a different approach. **Business ecosystems** (1), for instance, focus on collaborations between a number of organisations that together create offerings or use synergies. In the case of leather products, a shoe company could cooperate with a licenced shoemaker to offer a product-service-system by which consumers pay a monthly rate and can turn in their shoe at the shoemaker when it needs refurbishment or is damaged. Identifying businesses and services in the context of a specific product offers potentials to create new cooperations that can support sustainable development by extending product lifespan or establishing circular business models (see also chapter 5.4).

A more recent approach is to focus on customer experiences when analysing a product's context. **Experience ecosystems** refer to all services, products and spaces that create end-to-end experiences (2). This perspective – an experience ecosystem – places the customer at the center of the world to help make sense of their context.

Although experience ecosystems can also refer to new business cooperations, their focus could just as well be a different one. Risdon and Quattlebaum differentiate between eight types of experience ecosystem relationships (3). For example, if the conceptual design of a leather product (see chapter 5.2) aims to increase an emotional bond to the product and emphasising the natural, unique and ageing aesthetics of a specific type of leather, this could be adressed by offering products and services in addition to the product itself. A company could produce educational videos on youtube or publications that explain how to maintain the product correctly, what signs of ageing are to be expected or how to notice them. In addition, social media and other channels could be used to let customers share their experiences and stories around their unique products. Although these concepts may not be applicable to all companies or product categories, their purpose is to illustrate that focusing on the experience ecosystem does not necessarily have to be associated with other companies. However, in most cases this approach will require stronger diversification of a company's portfolio or activities.

In the context of sustainable development, one leverage point is to change consumer behaviour – be in the form of purchasing more sustainable products, using products for a longer period of time or, more generally, maintaining a product in a more sustainable way by using less hazardous chemicals, for example (see also chapter 3.4). Placing consumers at the center of the world and creating an ecosystem that facilitates more sustainable consumption patterns can be a helpful and effective tool.

Ecosystems as a Driver for Sustainable Development in the Context of Leather Products

Considering the various approaches and tools described in this handbook, ecosystems can pose a helpful approach to facilitate the use of them and create new business models. For instance, if customisation and versatility is part of the design concept, considering new service partners and additional offerings can strengthen the effectiveness and acceptance of this product.

Barbero and Tamborrini (4) present a number of comprehensive examples of the usefulness of this approach. The project "fondo noir" in collaboration with Lavazza (5) makes use of the various potentials and functions coffee and coffee grounds can be used for (see fig. 3.9.2). In this special form of ecosystem map, new use cases (and related business models) are mapped around the core product (here former waste) to illustrate the interrelatedness of items and processes.

At the same time, it is important to embrace the systemic perspective that is embedded in the ecosystem's approach with respect to rebound-effects and sustainable development. Understanding ecosystems of products enables design and development teams to gain insights on new potentials as well

as sustainability threads that are part of a specific innovation. However, this requires to pay full attention to the broader context of a use case. From a methodological point of view, it is therefore recommended to include research methods and users in the development process to collect first hand data and make design decisions based on evidence.

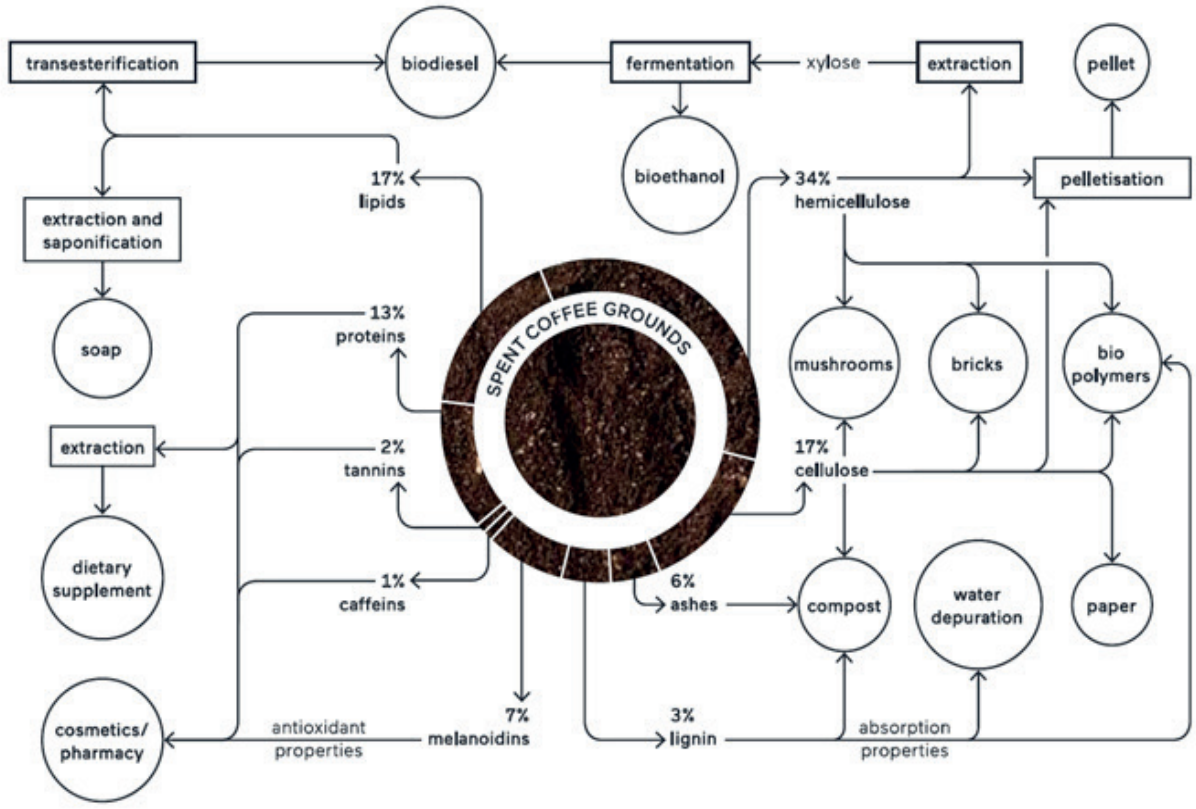

Fig. 3.9.2: Coffee Ground ecosystem (from Barbero and Fiore, 2014)

In the specific case of leather products, a systemic approach that focuses on the product's entire ecosystem offers further potentials for sustainable development. Taking a typical men's dress shoe again as an example (see fig. 3.9.1 at the beginning of this chapter). When purchasing a medium-priced model of this product category, consumers usually are offered shoe trees to maintain the shoes shape after wearing, as well as shoe cremes or other products to care for and clean the shoes. Sometimes consumers even apply waterproofing spray on their shoes (although this is not recommended, especially in the case of leather dress shoes and may cause more harm than good to the shoe, the consumer and the environment). If after some time the shoe shows scratches or is dirty, a consumer can approach a shoeshiner or shoemaker to refurbish the shoe or alternatively searches the internet and social media channels to gain practical knowledge on how to take care for the product themselves. All of these steps and actions directly or indirectly involves the use of some kind of chemical, which can have an effect on the lifetime of the shoe, the pollution and the exposure of humans and environment to potentially toxic chemicals.

Addressing these (and many other) steps throughout the lifetime of a leather

product from a sustainability point of view uncovers current harm as well as business opportunities in terms of sustainable development. Brands could provide services such as information channels to enable consumers to maintain their products with less harmful chemicals. In addition to that, brands and retailers could rethink their portfolio of care products with respect to chemicals used and their effectiveness, and offer different types of products or replace them with appropriate service offerings.

While these concepts are simple and general examples of the potential of this approach, comprehensive system analyses and ecosystem mappings can foster profound and practical solutions that can be both more sustainable and financially attractive.

The Role of Digital Services and System Elements

To further elaborate on the notion of information channels as an extended product ecosystem, digital services play a key role. In many cases, both leather as a material itself and leather products are rather associated with traditional values, longevity and robustness and less with digitalisation, high-tech or modernity[1]. However, digital services, social media and other virtual concepts can extend the current ecosystem of leather products and provide information as well as increase customer product loyalty. As mentioned before, both brands and private persons are using websites and social media channels such as youtube and instagram as platforms to provide useful knowledge and skills regarding specific products.

[1] A recent study conducted by this project team and other scholars of the University of Applied Sciences Darmstadt confirms these connotations: https://h-da.de/fileadmin/Einrichtungen/sne/sne_Results-Leather-Survey-2020_2020_10_22.pdf

Following the principles of experience design, adding digital services to the classic product portfolio can be a part of (re-)designing customer experiences that go beyond simply purchasing of a product. While customer experience design is usually seen as a way to increase sales and strengthen customer loyalty, it can also play a role in sustainable development as it can influence the way consumers behave and feel about a product or material. Thus, applying techniques and tools from experience design methodology can foster new business models and strategies and be beneficial from an economical as well as sustainability point of view.

Broadening the Scope

All in all, for companies and design teams to create more sustainable leather products, extending one's scope beyond the actual product is crucial. This is true in two ways: On the one hand, looking at the product's entire life beginning from the beginning of the supply chain to end-of-life scenarios is essential and discussed in several chapters of this handbook (e.g. chapters 4.2 and 4.4). On the other hand, and in addition to this rather chronological perspective, it

is recommended to also be aware of products, services and actors that are directly or indirectly related to the product or its use. While the former usually is obvious (although not less complex) as it directly relates to the production and use of the product, the latter requires profound research and analysis to clearly map the ecosystem at hand. However, this extra effort can be beneficial in the long run and is worth considering when creating product briefings, as it can foster innovative (and potentially circular) business models. When designing or improving product-service-systems, mapping and understanding the product's ecosystem is essential[2].

[2] For more information on product-service-systems and the various types of it, read chapter 4.4 on business models.

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Querencia by Amber Ambrose Aurèle, the Netherlands, 2015. Shoe inspired on an original Serbian opanak. Courtesy of Amber Ambrose Aurèle

4

Design Approaches & Strategies

A design approach is a set of design principles or techniques that focus on specific outcomes. In the context of this handbook, design approaches are paradigms that refer to certain issues that are in line with sustainable development. In some cases it might be difficult to draw clear lines between design approaches. Principles that refer to one approach might apply to another at the same time.

Although, the design approaches presented here refer to leather and leather products they can easily applied to other product categories. Some of them might even derive from entirely other industries and have been adapted to the context of leather products.

4.1
Design for Longevity and Reusability

Ann-Cathrin Jöst, Nina Conrad, Andrés Castro

Nowadays, leather production is most versatile. Leather is produced differently, in different regions and with different processes. These processes can range from the type of tanning agents applied on different types of hides up to the finishing used to achieve a specific product look and feature. Because of these differences, the quality of leather can vary as well.

At the same time, different processes and ways of designing a product can have an impact on the longevity of the material. Longevity means how long a product can be used without breaking down or how long it can stay in its original condition. Reuse, which is linked to longevity, refers to the products' opportunity to enter different market segments at the end of its life. This could be the case when a consumer wants to purchase a new product or when the product is no longer suitable for a specific need or market segment.

For both aspects, design plays an important role. Design refers to the way a product is constructed and how the leather of a product has been processed and thus, how it is later used in a design. The aspects of reusability and longevity are two different ones, but they are intertwined, e.g. as products such as leather shoes with soles that come off quickly or leather jackets with zippers that break easily are discarded more rapidly. Simultaneously, products with cheaply processed leather are also discarded more easily, regardless of how well the product system functions.

Leather Products and Longevity

Different factors influence how long a material can be used. For leather-based products, the type of leather used and the way it is cared for play an important role. For leather to last as long as possible, the most suitable type of leather needs to be used and the right type of product finishing and care should be applied.

Choosing the right type of leather is important

Leather is used in a wide range of products such as shoes/footwear (38%), leather goods (22%), furniture upholstery (13%), automotive/aviation (13%) and fashion (8%). For leather products to last as long as possible, it is essential that the leather is of high quality and that the properties of the leather suit the product. Before choosing the type of leather, it is important to think about the different properties of the types different leather.

Why do leather properties matter?

Depending on the origin of hides and skins, the tanning process and the way the following processes take place, the leather will have different properties in terms of breathability, softness, stretch, tear strength, UV resistance, soil resistance (including biodegradability) at the end of life. To learn more about this and the manufacturing processes, please have a look at: https://www.leathernaturally.org/Education/Fact-Sheets

What is the relation between leather properties, quality and longevity?

Apart from the impact on the longevity of the material, these different features can also lead to a different material quality that a consumer is looking for. For example, coated split leather is less suitable for furniture or belts because frequent friction puts a lot of strain on the leather. On the other hand, pig leather is very suitable for shoe linings due to it being thin and breathable. Kangaroo leather, known for its extreme flexibility, is suitable to use for sport shoes because its flexibility makes it great for soccer or running shoes.

The role of finishing in sustainable design

Finishing is the final stage of leather manufacturing where a coating of a mixture of resins, pigments and other auxiliaries is applied onto to the raw leather. It is used to achieve the required surface aesthetics and performance. Finishes can add colours on undyed leather, improve leather quality, provide protection (from oil, water, soiling), increase durability and even create fashion effects. While specific effects can be achieved with finishing, it can also influence how well a product can be cared for and maintained.

Most often the natural look of leather, or more specific aniline leather, is desired. This type of leather is known for its high quality, but also results in higher material costs. For this reason, split leather is often used, which is given a synthetic coating to make it appear in the typical leather grain. In other cases, a different finishing is used to achieve a specific look such as shiny pink (and of course other colours) or a specific feature such as water-repellency.

One disadvantage of that is that leather can lose its aesthetic appeal over time more easily or it can become difficult to care for, maintain and repair once the product pattern has diminished. In the case of a belt, the leather is often

strongly bent when it is put on and taken off. Over time, the coating can crumble off and reduce the products' aesthetic appeal. In addition, it may also reduce some of the functional properties (see image 4.1.1: Coated split leather).

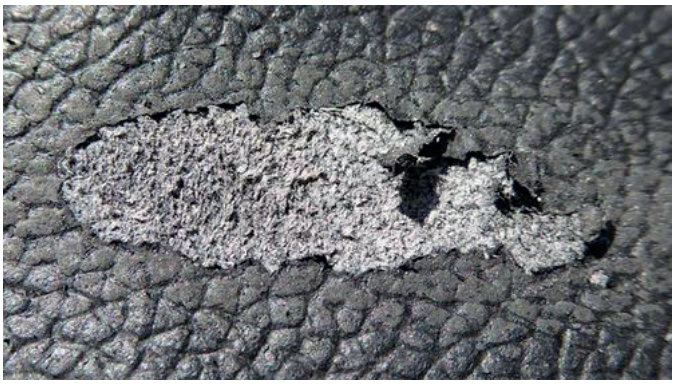

Fig. 4.1.1 & 4.1.2: Coated Split Leather

Should finishing be avoided?

No. Although leather could be processed without finishing, finishing is an important design aspect as it relates to the quality expectations of the product. Products with finishing can help the material withstands environmental influences such as rain.

From a sustainability perspective, it is advisable to go for bio-based or toxic-free coatings. Toxic coatings based on PFAS (bioaccumulative and toxic group of chemicals) can make it difficult to reuse leather and generally affect the consumer safety.

It is also important to consider that coating will wear off over time, causing the leather product lose „quality".

What appeal is there, to use only the most necessary types of finishing?
The beauty of leather is its natural ability to age over time and that change can be seen in vegetable tanned leather and aniline leather. As this leather ages, it takes on a vintage look and can therefore still used in a variety of ways in the fashion, furniture and other industries. Using a higher quality type of leather such as aniline leather is suitable for products to last and to be reused.

A product only lasts as long as it is properly cared for

Just as plants require different amounts of water or exposure to sun, the same applies to leather in terms of product care. Different types of leather have different characteristics and properties, which is why the effect of care products varies depending on the material. Wrong choosen care products can also damage or contaminate the material, which, in addition to a loss of material quality, can also threaten its further use (see chapter 4.2, Design for Recyclability).

How can products be properly cared for to last?

This differs depending on the product. Therefore, each product should be accompanied by care instructions. To give an example, for shoes in particular, a shoe tree is important so that they keep their shape and original appearance for as long as possible. Shoe trees should be used after wearing shoes and left in the shoes for the next 24 hours. High-quality full-leather shoes without shoe trees sooner or later lose their exceptional fit, develop severe creases and, if they are not dry enough, can also develop a warm, humid climate.

What does this mean for a designer?

For a designer, this means thinking about what type of leather is used for a product, what it means for the quality and care of the product and how best to communicate this to the consumer. A designer may also want to communicate the particular feature of the material, for example using white pigmentation to repel moisture. In terms of sustainable leather, a designer should recommend natural care products like beeswax as opposed to chemical-intensive care products. This is especially true for products with less use of finishing and more natural features.

Leather and Design Techniques

As previously pointed out, the processes involved in the production of leather and the way it is being cared for have an major impact on its durability and material longevity. These aspects also apply to the product systems of which leather is a part of. In the following a range of design options are listed that can support both leather and product system longevity.

Design to disassembly

While leather has a material life expectancy of around 100 years, the product system often does not. For this reason, the product is often discarded long before it reaches its end-of-life phase. Reasons for this can be malfunctioning product features, like a zipper that breaks, product lining that does not last, a shoe sole that is run off after one season, or other product parts that are difficult to repair. Therefore, a holistic approach regarding the construction of the entire product is needed during the design phase.

Think about a horse saddle. Most saddles are covered in leather and consist of a padding that makes riding comfortable. After a while the padding loses its supportive feature while the leather is still in good condition. Unlike many years ago, the padding of most saddles can no longer be repaired and the entire saddle is discarded. On older models, the padding could be repaired because most saddles were designed with a small hole through which the padding could be replaced. "Design for product-repair" was part of the manufacturing process. This concept can also be applied on to other industries such as the furniture and automotive industry.

Fig. 4.1.3: In the past saddles were designed for repair, today often less (photo: pixabay/maxmann)

The case of footwear

A leather sneaker is made up of different components, with the upper part mainly consisting of leather and the sole from other materials such as rubber. Unlike the shoe upper, the sole is often exposed to heavy wear. As it wears down with each step, the shoe loses important properties over time and simultaneously its functionality, such as the feeling of safety when walking on slippery surfaces.

Because the sole wears out, consumers tend to discard the whole shoe even though the upper part is still functioning. To make the leather sneaker last longer and not be thrown away, a shoe should be designed so that it can either be easily repaired or the sole can be replaced.

The Swiss brand VYN Switzerland provides its customers a replacement sole and a repair kit with the purchase of a sneaker so that the sole can be replaced at home (see Image 4.1.4: VYN Switzerland).

Fig. 4.1.4: VYN Switzerland Sneaker

Design to last a lifetime.

Some products tend to break easily, others do not. That is where "design to last" comes into play. These products aim at being manufactured in such a way that no material breaks easily and the parts are durable. The use of less materials and materials that last and are of high quality is an important design aspect.

Who designs shoes to last?

Products can also be designed in such a way that a product lasts a long time without the need for repairs or the like. As an example, the LLOYD 1888 line for shoes follows such a concept, combining higher-quality materials with other products. The materials are glued and sewn where necessary so that they do not come apart. At the same time, some product components can still be repaired.

What effect does "design to last" have on the material choice and their impact on sustainability?

It means that compromises have to be made in the choice of materials in order to obtain a product that is as durable as possible. Not all „sustainable alternatives" at first glance are suitable for production or for a long-lasting products. A cotton thread, for example, is less tear-resistant and can already tear during production on the sewing machine. The same applies to recycled PET threads, due to its properties.

To give another example, waxed linen threads cannot be used on machine seams, but only for hand seams. On the other hand, a vulcanised rubber sole has a small percentage of synthetic material, but its lifespan is much longer than that of a pure rubber sole.

Moving away from complicated designs - Reduce to the max

Nevertheless, several materials are used for a wide range of products. They can be replaced, but a designer can also think about how materials can be replaced the least. As already mentioned, the advantage of leather is its durability. This is especially true for footwear. While it is cheap to use a shoe sole that lasts a couple of months or a few years, over time the cost of replacement adds up to the cost of production and reuse. Is it possible to replace fossil fuel-based shoe soles with leather? Yes! The brand "VonMorgen" creates shoes that are made of leather.

Fig. 4.1.5: VonMorgen Shoe

What type of leather is best suites as a shoe sole?
Leather that has been processed for months is very resistant to environmental stressors such as material wear. In addition, a leather shoe sole is more durable than other materials. Although the shoes can be slippery at first, they become less slippery with use.

Other product features to support reuse

For products that are intended to enter new market segments after product use, these products need to be designed in such a way that parts can be easily replaced. This is important because new customers may think that used shoes are unhygienic. For shoes, this means that it is easy to insert a new insole with a replaceable footbed for example.

In terms of design, a brand could put a unique symbol on the product that directly connects customers to the emotional value of the product (see chapter 4.5) or put a QR code on the product (see chapter 3.5 on Traceability) to get more insights into the history of the product. Because of the emotional connection, the customer wants to keep the product longer.

In addition to illustrating a story line around the product, a QR code can also be used to support circular business models, by offering return services integrated into a reverse-logistic system for example (see chapter 4.4 on Business Models).

Business Models Incentives - Reuse

Sometimes the production of more durable products can be more expensive in terms of time and money in comparison to less durable products. To compensate that, new business models can play an important role;

C2B: Some companies offer restore services for products to extend the life of products. One example is the company Burberry, where leather goods can be sent to selected local stores for reprofing and repairing. There the product

receives special treatment, either to maintain the waterproof characteristics of leather or to carry out replacement, fixing or re-conditioning of leather goods. Ownership of such a product is an important factor in the success of this model. On one hand, a customer places more value on a luxury bag or coat and therefore considers it important to extend its use-time by using the repair and care services offered by the company. On the other hand, it also represents a new business opportunity for the company, in which a service is offered in most of the cases with a financial retribution, and in the specific case of this brand, to restore its public image about environmental concerns.

A similar approach is the "Worn Wear" program of Patagonia. Since 2011 they have implemented a strategy to reduce the quantity of garments going to landfill or incineration. As mentioned in the programmes, the first strategy is to reduce overconsumption, followed by developing strong repair programs so that people continue to use clothes they already own. Interesting fact, it is based on workshops reaching people directly in communities, where repair services are offered but also knowledge transfer about care of products and basic repair techniques.

Patagonia also supports and encourages programmes for reusing clothing that are in a good condition, making use of in-store events, tours and e-commerce platforms to resell clothing that is still in good condition and can be reused. They also promote the resale of used clothing to employees and donations to organizations and groups in need. Moreover, an important policy of this programme is that the company does not use services that sell or donate used clothing to developing countries, as these practices could potentially destroy local business and shift a waste problem from developed countries to developing countries. If donations are indeed destined for developing countries, certain measures are taken to ensure that donations are truly needed and reach the specified recipients. At the same time, items donated are marked "no value" with a permanent stamp to prevent abuse or further handling. Some companies, such as Our Choice Fashion, offer take-back services where an item is upgraded and returned to the customer. Easy disassembling the shoe allows for a quick repair and ensures that repair services remain profitable.

Conclusion - Choosing the Best Design Method is Product and Market Dependent

Different types of leather have different features and therefore different use-cases. This makes it difficult to generalise which type of leather is most suitable for which type of product design. Product design depends on the intended life cycle of a product, while the intended life cycle of a product depends on the product system and its related business models. Regardless of the business model and product system, it is recommended to use high quality leather and leather that matches the specific product features, kangaroo leather for

flexibility for example. Although leather can last a lifetime, products need to be properly cared for. This is possible if consumers are provided with proper care instructions or if product maintenance services are part of existing business models.

References

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[3] https://www.vyn.one

4.2
Design for Recyclability

Andrés Castro

Recycling is one of the circular economy strategies used to recover the value of materials in a product at their end of its use phase. The European Union defines recycling as:

"any recovery operation by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations"[1]

[1] eurostat, 2022: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Recycling_of_waste

In this sense, leather is a material with properties that are suited for the production of high quality and long-lasting products, besides its aesthetic and application versatility. However, there is no big perception of how leather can be recycled, or even more important, how leather products can be designed for a higher recyclability.

In the specific case of leather and its applications, there are several use cases in different industries, all of which trigger a specific consumer behavior in terms of ownership of products, as well as the end-of-life options available and their lifespan. For example, a pair of shoes is used for a long period of time, but may be quickly discarded due to sole wearing, although they are still in good condition. Thus, the leather part of the shoe may be lost if not a correct end-of-life alternative is offered.

In this regard, the circular economy gathers together a group of alternatives to reduce waste of materials and increase their integration into other products and processes. Recycling is one part of these alternatives and there are multiple opportunities for leather to be recycled. However, it is important not to underestimate strategies such as longevity, reuse or repair (see chapter 4.1), which can be also suited for leather products. Furthermore, by understanding the key differences between those strategies, we can dedicate resources and time to achieve the most efficient and environmentally meaningful measures from a design perspective. For example, recycling differs from other strategies such as reuse or refurbishment to the extent that materials and products are at their end-of-use phase and are intended or required to be discarded. This involves a process, which can be mechanical, chemical, or biological to recover the value of the materials either in the same value "Recycling", a higher

value "Upcycling" or a lower value "Downcycling". Also, the way a designer can address recycling alternatives depends on each individual product and design concept, and the current financial, technological and logistical barriers for recycling that exist for most of the targeted leather products.

It is important to note that increasing the recyclability of leather by design requires focusing on key areas such as **production techniques**, in which physical properties of leather are preserved even after certain mechanical processes, as well as the **use of safe chemicals** that do not obstruct handling with leather at the end of use.

Additionally, the **disassembly of leather** at the end-of-use phase plays an important role in recyclability, as it makes it is easier to direct leather to the most material-efficient and best-suited recycling process. It is also important to avoid **mixing with other materials**, that could either reduce the efficiency of the recycling process or the hazardous substances contained in the other materials that could even obstruct leather recyclability.

Combining those variables makes it more promising for leather products to increase their recyclability while being more compatible with the recycling systems currently available. Furthermore, understanding the concept of recycling and improving recycling practices in the leather industry can contribute to achieving a more efficient use of resources and potentially decreasing its environmental footprint.

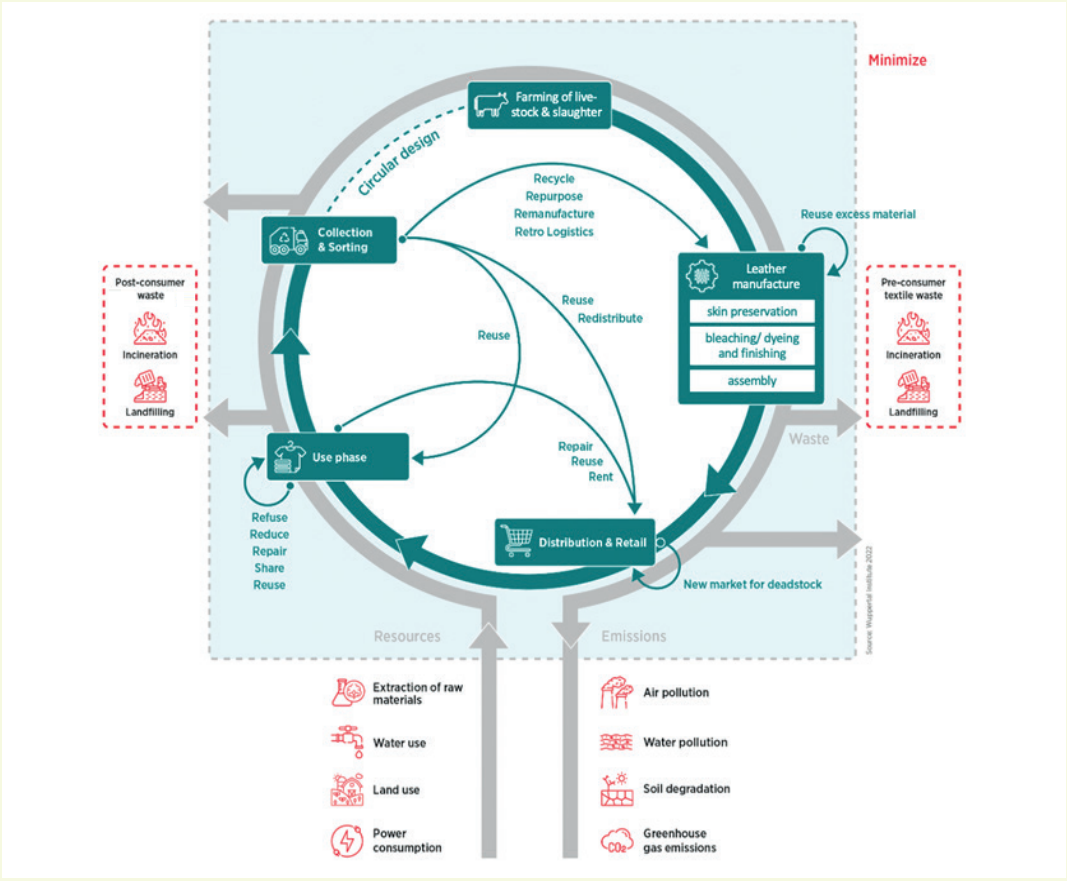
Designers are undoubtedly faced with the challenge of integrating those new concepts and applying them to a product that is meant to last longer and preserve its value, as in the case of leather, while at the same time thinking about how it can be recycled. Therfore, this chapter aims to provide clarity on the concept and analyse the main actions to promote the recyclability of leather in the design phase.

Focus: The circular economy concept for the leather industry

by Burcu Gözet, Wuppertal Institut Germany

As environmental pressures of the leather industry are generated along its entire value chain, a holistic transformation of the industry is required: Away from the linear take-make-dispose model towards closed loops, in which waste flows are minimised or reintroduced into the system as secondary raw materials. It is the concept of circular economy that provides such a systemic approach and is therefore discussed in the following. The figure below presents the circular economy and its conceptualization for the leather value chain. It involves circularity measures at each phase that have the potential to minimise both pre-consumer and post-consumer waste, and therewithin, direct and indirect environmental pressures. Within the process of envisioning a circular economy, the circular design of goods and products is a paramount as it can ensure a product´s longevity, reusability, and /or recyclability. It is also the design phase that determines future circularity measures that can be undertaken throughout the value chain, such as repair or repurpose activities.

Along the production phase, measures can be implemented that reduce the generation of textile waste through, for instance, the reuse of excess materials. Best practices are known, in which tannins and chemicals are recovered from excess materials i.e., shavings. A dedicated role in implementing further measures can be assigned to retailers and end-consumers. While the former can create and/or engage with marketplaces for the reuse of e.g., deadstock and/or provide repair services, the latter can reuse and share products that are already on the market, conduct maintenance, and take repair services. If, after all, leather products are no longer usable at a certain point and end up in the collection and sorting system, efforts are supposed to be undertaken to return those products back into the system (at its highest value possible). This can be done through remanufacturing, repurpose or recycling activities.



Among those strategies that can be conducted throughout the supply chain, it is due to the specific property of leather that certain circularity measures can be highlighted. If, for instance, leather is being properly maintained and correctly deployed, it can unfold a relatively long lifespan. A design for longevity combined with a clear communication towards consumers on the product´s maintenance should therefore be given a higher priority than to a design for repairability or recyclability. The use of leather predominantly for durable products serves thereby as a prerequisite.

Following this approach, the creation of transparency along the value chain and collaborations among stakeholders remain crucial. Circularity efforts within the textile industry have shown that new transformation measures come along with lots of questions and a certain degree of insecurity. Sharing not only best practice examples but also obstacles and concerns towards the implementation of certain measures have therefore proven to be beneficial for all stakeholders involved.

Status Quo

Recyclability is not an entirely uncommon concept for the leather industry. In fact, leather itself is in many cases considered as a "recycling" solution of a by-product (hide and skin) of the cattle and meat industry. Otherwise, those valuable materials could end up in a landfill or being incinerated. Moreover, the outstanding characteristics of leather makes it a valuable resource for many applications and certainly offers potential value for alternative uses and applications. Leather designers and producers can address the recycling of leather either at the pre-consumer level by recycling shavings, cuttings, leftovers, and offcuts or at the post-consumer leve by recycling finished products along the value chain of the textile, automobile, furniture, among many other industries.

Pre-Consumer Recycling

The term "pre-consumer" refers to all processes before the leather product is ready for consumer use. Currently, leather production generates splits, cuttings, trimmings and shavings as by-products, which in some specific cases have potential to be recycled, or more specifically downcycled. For example, splits can be used in the production of gelatine and collagen, as well as for the recovery of chemicals and their reuse in tanning processes. Similarly, shavings can be used for the production of leather boards, which requires chemical processing and adding rubber latex, before shavings are pressed and used to produce inner soles and linings for shoes. Additionally, the shavings can be composted and used to manufacture new biochemicals, which in turn are used again in the leather production[1]. For more information on the biodegradation and composting of leather, see an interesting whitepaper from Royal Smit & Zoon (1).

[1] See e.g. LANXESS Approach: https://lanxess.com/en/Media/Press-Releases/2020/08/LANXESS-starts-series-production-of-modular-X-Biomer-plants

Post-Consumer Recycling

In contrast, post-consumer recycling involves leather that has reached the end-of-use phase and can be collected and processed for the same or a different use. The recycling alternatives depend on the collection system available and the way leather was assembled in the product. Due to the wide range of uses and applications of leather, it can come in many forms and can be attached to different materials. It can be bonded with plastics, metals, foams and rubber, for the use in shoes, but it also be provided with just some pigments and coatings, for the use in certain wallets. This variety favours different approaches for recycling, not just mechanical but also chemical and biological recycling. However, for simplicity reasons and to address the goals of this chapter, the focus is on mechanical recycling of leather, which should not discourage designers to further research ways to improve and enhance other forms and techniques of recycling.

Having considered that, the main recycling option for leather is based on collecting products containing leather and shredding them into granulated materials. This process includes a pre-disassembling process, if necessary, to avoid problematic substances contaminating the outstream. Additionally, after shredding, the granulated materials are separated by different techniques such as density or air separation to finally obtain leather granulates. The final output can be used in applications such as sport surfaces, playgrounds and running tracks. British Airways, for example, has donated leather from short-haul plane seats after a lifespan of 12 years to social enterprises, which use it to make leather goods in various sizes. To give another example, Scottish Leather Group (2) accepts leathers back after its lifespan, to convert it into energy through gasification in their specialised thermal energypPlant.

Nevertheless, one of the crucial factors here is the collection systems. As mentioned in the chapter "Design for Reusability", large amounts of leather products end up in landfills or are incinerated without the possibility of recovering them for further reconditioning or recycling. Even in the cases where collection systems exist, sorting processes are necessary to separate the products into categories that can be recycled. However, this faces logistic and economical barriers, which makes it not a common practice for products containing leather.

However, there is another point to consider, namely the growing interest and presence on the market of goods made from discarded leather parts. Some examples are:

1.Footwear soles made from leather scraps

Fig. 4.2.1) Chromefree Leather Alliance - Jake Sketch
[https://www.chromefree.org/post/upcycling-leather]

2. Southwest seat to soccer ball

Fig. 4.2.2) By Dennis Schaal
Photo: Skift [https://skift.com/wp-content/uploads/2014/07/140710soccer_recycle_1_1_.jpg]

3. Leather Upholstery

Fig. 4.2.3) Beam Bench by Elvis & Kresse
https://www.elvisandkresse.com/collections/at-home/products/beam-bench?variant=39598153400401

4. Sneakers

Fig. 4.2.4) Straight Leather by Peterson Stoop
Peterson Stoop [https://petersonstoop.com/products/custom-straight-leather?variant=30283143807057]

While these methods of upcycling leather are found at a smaller scale and cannot yet be considered as a widespread practice in the leather industry, they show how the current market is encouraging the recycling of leather in different forms and for different products.

Design Factors for Leather Recyclability

As we have seen, recycling is a complex topic, especially for leather, and it brings many economical, technical and logistical challenges that cannot be solved by one company or one designer. It would rather be a joint task of industrie, lawmakers, consumers and other stakeholders of society. However, there are certain efforts that designers can make to improve leather recyclability.

Material/ substance variety: The recyclability of leather can be positively influenced if mixing with other non-recyclable or no-compatible materials is reduced. For example, if a leather part with a metal component is glued in a product, the recycling of leather becomes very difficult due to the current sorting techniques in the recycling process, where magnetic and semi-magnetic properties are used to separate streams of materials after shredding. A lower number of materials in a product facilitates recycling, moreover, it can also enhance material efficiency and collection rate of materials. Additionally, adding coating, paints, softeners, plastifiers, fire protector chemicals, etc. should be reviewed and evaulated if they are really needed or if there are bio-based alternatives available. That is to say because certain substances of very high concern can hinder the recycling process. Also, many of the added chemicals can change the physical and chemical properties of leather, making it more difficult to be upcycled in terms of appearance and mechanical properties, but also in terms of the purity of the streams of granulated leather particles at the end of the recycling process. Furthermore, labels and stickers on the surface of leather should be avoided. These materials typically contaminate leather and are not easy to take off. An example of an initiative to develop a biodegradable sneaker is the RE:SUEDE by PUMA, where a sneaker was developed using Zeology tanned suede, biodegradable TPE and hemp fibres.

Management of chemicals: "Safe by Design" is a key concept, not only to enhance recyclability, but also a compliance criteria for any product. Hazardous substances should be avoided and if they cannot be avoided, they must comply with chemical regulations such as REACH in Europe, but also initiatives such as Zero Discharge of Hazardous Chemicals (ZDHC). Moreover, efforts should be made to reduce the quantity of these substances. It must be ensured that a product is safe and does not contain hazardous materials or substances that are in any way harmful to humans or the environment along the life cycle of the product (this also includes the recycling phase). Furthermore, it must be ensured that a product can be easily collected and safely recycled without decreasing the quality of the recycled outstream or negatively impacting the environment.

Disassembly of leather in different products: Facilitating the recycling of leather requires an easy way to disassemble leather from the main product, which is not easy for many products where leather is part of a compound material. Therefore, easy removal of the leather should be enhanced to avoid damage in leather that could affect its quality and the possibility of its use for upcycling proposes. Furthermore, the efficiency of shredding in a recycling path is increased if the materials are pre-sorted and "unbreakable" compounds, such as leather pieces glued to plastic or metal, are avoided.

Here, a rule to ensure disassembly should be: Plugin or stitching connections are preferable to screwing and screwing is preferable to gluing.

Modularity: A modular design increases recyclability in a similar way easy disassembly does. First and foremost, a modular construction facilitates an easy disassemble of the leather components without much effort, as modules have already been designed for each important part of the product. Moreover, it can also be useful for designers to enhance repairability and maintenance of leather. In many cases, such as a shoe, the product would be discarded not because of the leather parts, but rather because of the sole or heels. If it is possible to make spare parts available (ideally online so that consumers can order and replace them at home), this could help to ensure that parts that can no longer be used are simply recycled or, respectively put into the correct collection system to be recycled more efficiently.

Collection Systems: Thinking ahead of collection and take-back systems is an interesting and certainly useful strategy to enhance not just recyclability, but also all actions of the circular economy. This task is not just exclusive to a designer, but it should be also addressed in the development of products and company strategies. This is where the conception of innovative action fields, such as modularity and compatibility of new parts with old products, can be taken into account. Let's say that a take-back programme is put in place for leather bags and the new leash connection is not anymore compatible with the old buckle of an old bag. This makes it difficult to refurbish or reuse the leather bag because their old components are not available anymore. The fact that products can return to production and continue to be used provides a variety of possibilities for designers to avoid obsolescence of products and make it more suited for extension-of-life alternatives. If that is not possible, they can be sent to recycling facilities for efficient recycling. For example, Emma Safety Footwear focuses on developing circular footwear and is connected to the Circular Footwear Alliance, which collects used footwear.

Case Study

The safety shoe line "Circular" of the company Emma Safety Shoe, part of Hultafors Group in the Netherlands, was selected as a case study. This company focuses on the production of safety shoes according to the principles of the circular economy and has been researching and developing new products since 2015.

Material/ substance variety

In the footwear design process of the company, leather is an important material and widely used, mainly because of customer preference and its durability. The production of leather starts in a tannery in Brazil that has been certified with a gold status by the Leather Working Group (3). To to receive this certification, tanneries must fulfill, among other requisites, a scheme for water reuse and the use of pre-consumer waste to produce for example, gelatine, colagene and fertilizers.

Although leather is a main material, evidently, there is the necessity to use a variety of materials such as metals, plastics (thermoplastics), coatings and composites. That is why, each shoe has a "product passport" which contains the specifications and percentage composition of materials used, as well as an own classification system of more sustainable materialsbased on the Cradle to Cradle methodology and the list of suppliers. This product passport promotes transparency for customers, suppliers, producers and waste management companies. Also, it gives the designers and producers the possibility to understand and see what is inside the shoe, what its function is, as well as which problematic materials can be substituted or reduced.

Management of chemicals

The company has also implemented a chemical management system throughout the supply chain, focusing on the use of safe chemicals that have no negative impact on the environment and are suited for recycling processes. Nevertheless, challenges arise in the design process when trying to fulfill technical requirements (ISO Standard / European regulations) while enhancing recyclability. One example is the requirement of leather in safety shoes to be water resistant for at least four hours. To ensure this, it is necessary to use finishing processes, in some cases top layers of PU, which affects the recyclability of leather. These kinds of decisions are crucial in the design process and innovations are sought for in this area, where safe and economically feasible solutions are an option, but still require collaboration and a strong analysis of the new substances or techniques to be used. Currently, this process is supported by a LCA, which calculates the environmental impact and serves as a base for decisions on the implementation of alternatives for chemicals.

Disassembly of leather / Modularity

As mentioned previously, transparency of materials in the products is key to enhance recyclability. Additionally, to assure the disassembly of the products, Emma shoes is working together with the Circular Footwear Alliance under the concept of "Designed for Disassembly", where ways to disassemble the products are defined and standardised. Also, the modularity of shoes is thought ahead, with some innovations such as the use of fewer components and the use of longer pieces of leather instead of small pieces, which facilitates the correct sorting of leather.

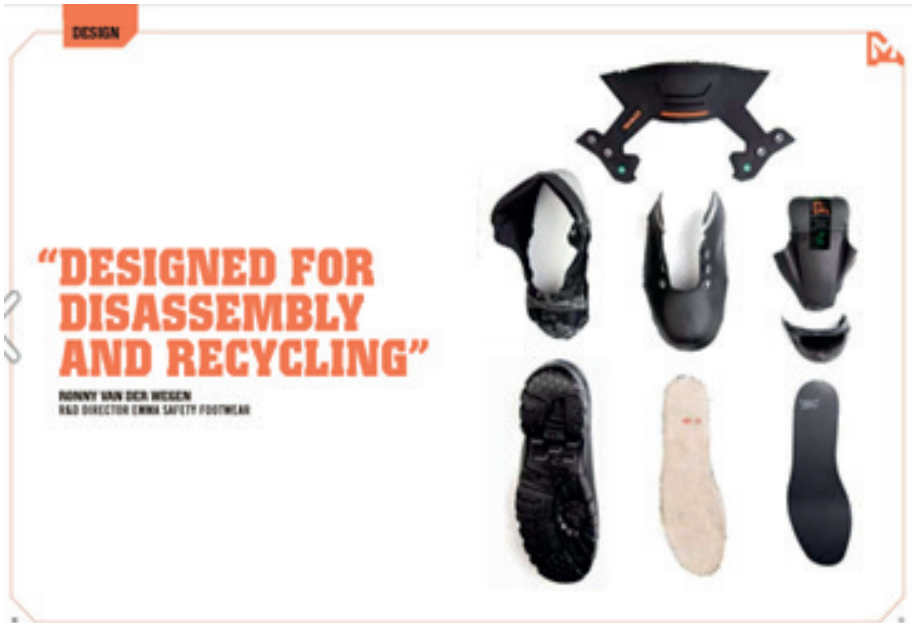


Fig. 4.2.5)
Disassembly Shoe
(Source: Emma Safety Footwear)

- 1 Recognise the trail of destruction, know the trail of innovation
- 2 Create 100% visibility and transparency of raw materials and production
- 3 Give your products an identity
- 4 Develop to suit the useful life of the product
- 5 Design to recycle (dismantleable and develop with pure flows)
- 6 Design with as much reuse value as possible
- 7 Guarantee positive working conditions with growth opportunities
- 8 Make sure that everyone can be involved in the employment process
- 9 Produce efficiently and where possible within Europe
- 10 Make use of reclaimed raw materials (urban mining)
- 11 Produce zero waste and zero emissions
- 12 Actively share and gather knowledge and skills in the cycle
- 13 Continue to take positive steps forward

Fig. 4.2.6)
The Positive Footprint scheme
(Source: Emma Safety Footwear)

Collection Systems

Emma shoes collaborates with the Circular Footwear Alliance to collect and take back worn safety shoes. The reverse logistic works with collection points which can be ordered by any company in the Netherlands and Belgium. After the collection, the shoes are sent to strategic partners who take over the dismantling process and ensure appropriate recycling or other use of the materials. It is important to note that these collections points are not brand-specific, i.e. many of the shoes that end up there do not come from the associated companies. Therefore, a pre-sorting between "circular" and "non-circular" safety shoes is done. The circular shoes include a product passport and a predetermined end-of-use specific application, which facilitates the efficiency

and recycling rate. However, the composition of the non-circular shoes is unknown and certain substances of concern may be present, which means that additional steps are taken to determine the best suited application for those materials or, in many cases, their energy recovery.

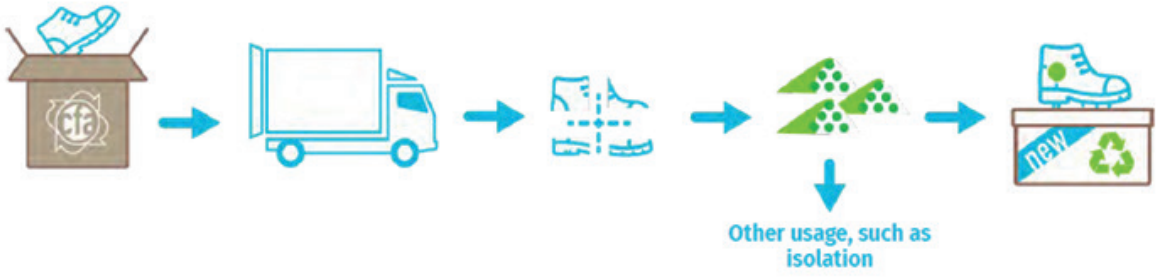


Fig. 4.2.7) Collection System by Emma Shoes (Source: Emma Safety Shoes)

This is an assertive approach initiated by EMMA shoes and their willingness to enhance the circular economy, as a sustainability strategy for the company. Moreover, it does not just involve vertical cooperation with suppliers, producers and other stakeholders of the value chain, but also is a result of collaboration with competitors in the market, which are seeking the same sustainability goals.

Conclusion

In summary, leather as material has properties suited for circular economy models. These include its durability, application versatility, as well as customer appreciation and ownership to leather products. For this reason, designers can think ahead and influence the path that leather can have, even at its end-of-use phase, where it can be introduced to new cycles and preserve its value. This is possible if product developers and designers include and implement key concepts of "Design for Recyclability", as outlined in this chapter, but also depending on the type of product, take target audience and product functionality in consideration. In this context, it is important to understand the properties of leather and other additional substances that are added to achieve the desired material characteristics. More precisely, to understand how these substances can influence product recyclability or how compatible they are with the current collection and sorting waste systems. In this way, not only are the toxicity of the substances and the related impact on the environment and on people manipulating these materials in a recycling process taken into account, but also their emissions to air, water and soil. Similarly, designers can also influence a product at the structural level, making sure that construction paths and techniques do not obstruct sorting processes. Furthermore, to facilitate leather integration into recycling processes and, for instance, allowing for modular product configuration, this is a great strategy for designers to facilitate the disassembly of valuable materials such as leather and their efficient integration into recycling.

To accomplish this implementation of factors of design for recyclability at the material, but also at the structural level, designers certainly face several challenges and a necessity for a paradigm shift in the current production linear model to a circular model. Producers and designers understand the importance of including design for recyclability concepts, but at the same time, companies are willing to adopt these initiatives to support and promote the transition to the circular economy, and work in line with the conception and ideas presented in the design phase. As the case study shows, it is not just a task of a designer or a producer, but rather a common task/ challenge for industry itself, where collaborations and synergistic strategies can be game-changing factors to ensure the design of products that can be recycled at their end-of-use phases, and similarly, that recycled leather applications can expand their presence in the commodity market.

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4.3 Material Selection

Ekkehard Werner, Karen Lehmann, Nina Conrad, Jonas Rehn-Groenendijk

Leather is a versatile and complex material that can add both aesthetic appeal and functionality to a product. Therefore, material selection is a crucial part of the design process having an impact on many aspects of the final product. With regards to leather, there are a number of parameters design teams should consider. While the type of tanning is certainly the most popular aspect of leather variety, the origin of the hide, the type of finishing and other aspects interrelate with the type of tanning and synergistically create a specific material that is more or less sustainable – depending on the use case.

Type and Origin of Hides

Not every type of leather is suitable for every application. So choosing the right leather for a defined product starts with the animal species. On the one hand, size and thickness differ depending on the animal species: The hides of cattle are large and thick hide, while the skins of lambs, sheep and goat are small and thin. But not only size and thickness differ depending on the animal species, especially the skin structure varies a lot: A hide or skin can be stiff, elastic, tear-resistant, breathable, two-layer, just to name a few properties.

Even within one animal species, leather can have very different properties and qualities: Hence, the skin of a cow differs from the hide of a bull. The age of an animal also plays a big role on the structure of the skin and thus also on the finished leather: For example, the hide of a cow is much more elastic and also thinner on the belly than on the back. These different qualities are used to make different products. Furthermore, the younger the animal, the less marks and scars a hide might have. For this reason, the hides of a calf are usually more expensive than the hides of a cow.

As hides from cows and bulls are typically stronger and thicker, they are - in many cases - more suitable for shoes or leather bags. On the other hand, hides from lambs and goats are thinner, lighter and softer. When designing a light women's leather jacket or soft purse this could be the material of choice. The provenience of the leather also makes a difference as the rearing of the animal impacts the produced leather: Whether an animal has lived in nature

or in a stable, whether it comes from a fedlot or from organic farming, this can also be seen in the appearance of its hide. The fast growing of a cattle leads to wrinkles in the skin structure, while animals living in the wild are more likely to be exposed to injuries from fences or bushes.

Fig. 4.3.1) Size, thickness and other physical properties of leather directly depend on the type and origin of the hides used.

From a sustainability point of view, using originally thick types of leather for usages that require thinner material is not only more expensive due to additional manufacturing steps but also creates more residual material from cutting, which could either enter further processing or become waste. By selecting a more appropriate type of leather in the first place, production can be cheaper and more sustainable.

For more information on the effect of the type and origin of the hides see chapter 3.2 on supply chains.

Type of Tanning Method

Depending on the tanning method, leather has specific properties that influence - and limit - its areas of application. The three most important tanning methods today are chrome tanning (wet blue), aldehyde tanning (wet white, often referred to as chrome-free) and vegetable tanning. In recent years, a number of new tanning agents from olive leaf extract, rhubarb extract or other vegetable or mineral sources (e.g. zeolite) have come onto the market. These alternative tanning materials and methods currently serve a niche market. Availability and cost limit their application and diffusion. Each tanning method results in a different leather with different properties that meets different needs to different degrees.

Chrome tanning is the most widely used tanning method: around 80-85% of the leather produced worldwide is tanned with chrome salts. The reasons

for this are on the one hand the low cost and easy availability, but also the beneficial leather properties such as light fastness, heat resistance, tensile strength, low weight and high functionality. If used correctly, chrome salts are unproblematic in tanning.

After the use phase, articles with leather are usually collected via household waste and thus often disposed of via thermal recycling. The incineration of chrome leather in disposal plants can lead to a reaction of chrome III to chrome IV. Avoiding this requires adapted process technology, for which at least sites in e.g. Germany are equipped. However, it is a general goal of environmental policy to avoid or largely minimise the input of heavy metals such as chromium into the environment via waste, sludge or wastewater. The legal requirements for handling heavy metals are therefore generally the focus of approval and monitoring procedures.

Fig. 4.3.2) Example of upholstery made from chrome-free (here vegetable tanned) leather (photo: Wolkenweich & Ecopell)

In the production of leather for upholstered furniture, chromium-free materials such as aldehyde or vegetable (fig. 4.3.2) tanning agents are also used. Depending on the application, the use of chrome leather continues to be preferred in the furniture market, e.g. due to the large selection of product ranges, e.g. of available colours. Chrome-free leathers, on the other hand, are used in the automotive industry in particular.

In aldehyde tannage, glutaraldehyde is commonly used. Although this synthetic tanning agent is very toxic, it does not endanger workers when handled properly, and no residual concentration of agents with aggressive crosslinking potential remain in the leather. Aldehyde-tanned leather is usually re-tanned with a vegetable tanning agent; often tara or mimosa is used to make the leather fuller.

Vegetable tanning is an ancient process, which regained in popularity in recent decades (fig. 4.3.3). Vegetable tannins from different trees are used as tanning agents. Depending on the plant, the wood, the bark, the fruit or the root is used. The most common are quebracho, mimosa, chestnut, tara and oak. All tanning agents have different properties and give the leather a different characteristic and colour. Mixtures are usually used.

Fig. 4.3.3) Children's shoe made from vegetable tanned leather (photo: Pantolinos & Ecopell)

Apart from the nowadays typical drum tanning process, vegetable tanning processes can also be performed as pit tanning. This rare process takes several months. which is used, for example, in saddlery, for shoe soles, orthopaedics or belts.

Currently, the process also has a comparatively high water demand and, due to lower material efficacy and lower and slower absorption into the animal skin, the waste water contains more residuals than with comparable tanning methods. The advantage of this method, however, is that the substances involved are not based on fossil raw materials. Vegetable-tanned leathers are definitely a modern and appealing material in certain applications such as bag-making or sole leather. Vegetable-tanned leather often has a better image and is thus perceived as more valuable. The colour palette is very warm and the leather becomes more beautiful with time and use.

The percentage of products on the market, which uses entirely vegetable tanning, is thus far, compared to an industrial scale production, relatively low with about 10 %. Slightly more common is a chrome-based or aldehyde-based tanning process with a vegetable re-tanning. Though vegetable tanning has considerable advantages regarding its environmental sustainability, due to limited access to natural resources, the scaling possibilities of this method are limited. Currently, vegetable-tanned leathers are also significantly pricier and often have less favourable technical properties than chrome or aldehyde tanned leather. They are less heat resistant, limited in their colour range and not lightfast.

To complete an assessment of the different methods, a thorough investigation of the ingredients' supply chains is essential. Although chrome mining mainly takes place for the production of metal alloys, when used for tanning, the circumstances under which chrome is mined need to be assessed as well. Regarding the tannins, one might ask, how the natural tannins such as bark or leaves are sourced, where and how the tanning agents are subsequently produced and how long the transport routes are.

The selection criteria concerning the suitable tanning process for a finished leather or leather products commonly are aesthetics, price, quality and positioning with regards to sustainability. The relative sustainability is defined through different factors, usually including amount of material and chemical usage. Each buyer might weigh these factors differently due to preferences or market placement.

Finishings

Apart from the animal species and the tanning process, the finishing of the leather has a strong influence on the aesthetic appearance and functionality of the final material. The finishing determines the final touch and feel of the

leather. There are a number of techniques and processes to treat leather after the tanning process such as milling, polishing, burnishing, oiling, coating, embossing and lacquering (see also chapter 2.3 Taxonomy of leather design methods).

Depending on the use and demands on the leather, different finishes are suitable. An untreated aniline leather is open-pored and sensitive to moisture and dirt, and for this reason not suitable for all applications. However, if the leather is worn directly on the skin, such as on a shoe or watch, it makes a lot of sense to use undyed vegetable-tanned aniline leather in order to have as few chemicals as possible in direct contact with the skin.

While there is no strict formula regarding what type of finish is the most sustainable for a particular product, design teams should carefully consider what the environmental impact of a certain type of finishing is and what the benefit of using it will be (e.g. extended durability). Choosing a specific type of finishing always has to relate to the particular use case at hand. In some cases, there might be several options available that need to be evaluated using for instance a life-cycle analysis. Considering more natural or ancient processes of finishing can be both more sustainable and pose addition creative potential for design processes. With regards to circular economy, finishes can have a huge impact on the recyclability of leather. This is especially true for the most commonly used polymer coatings. This also means, for example, that heavily pigmented leathers are difficult to biodegrade without further pre-treatment.

Appropriateness of Material Choice

Leather production can be understood as a modular construction system, whereby it is possible to produce a material with vastly divergent properties. Therefore, making general claims regarding specific functionalities is quite challenging. Instead, it is advised to seek a leather conducive to the envisaged use case.

To illustrate: The demand on leather for a jacket, for example, is different from that for a shoe. For a leather jacket, we need a material that is as light as possible and breathable. Since synthetic and chrome-tanned leathers are lighter than vegetable-tanned ones, we would choose one of these two tanning methods. Also, since the leather should be very light, supple and also thin, a lamb or kid leather is more suitable than a thick cowhide.

For a shoe, on the other hand, we need other properties: For the lining and the sole, which can be in direct contact with the skin, we would opt for vegetable-tanned, undyed leather. This is breathable and also has the advantage of inhibiting bacterial growth. Since the upper is exposed to a lot of stress (pressure, movement, dirt, knocks, wetness), it makes sense to use a robust leather that can withstand these impacts. A vegetable-tanned leather is more

dimensionally stable, while a synthetic or chrome-tanned leather is softer and more supple. A surface coating makes a shoe water-repellent, but also less breathable. However, if the leather is not dyed and only pigmented superficially, you risk unsightly spots if the pigmentation comes off as a result of using the shoe.

An example of the different aspects to consider are leather seats in aeroplanes. Due to its fibre structure, leather has high strength properties. This makes it, in general, a good material for the furnishings of an aircraft, which are usually operable for around 30 years before retirement and, therefore, require high durability of all components. However, to find the right leather, there are other aspects to consider. One of them is fire resistance: In aeroplanes, each constituent part must meet strict standards, e.g., flammability and fire behaviour. In general, many spaces, such as public buildings, are subject to strict fire hazard standards.

Another consideration is weight. Leather, in general, has a comparatively high specific weight. A thicker leather would be more fire-resistant than thinner leather, which would indicate an advantage of using thick leather for the seats. However, thicker leathers are heavier, and another goal of the constructing engineers is to lower the aircraft's weight and thus energy consumption. In this case, one must find a good balance of different needs.

In terms of leather seats in aircraft, durable thin leather, chemically treated to meet the fire resistance standards, is used in the end. This example shows the different requirements on the functionality of a material, for which a good compromise must be found.

Fig. 4.3.4) Aircraft seats with leather covers (photo: unsplash/jc-gellidon)

As the examples show, leather can be configured to fit different needs. Therefore, the designer needs to know which properties are significant in their specific use case. Did the designer choose leather as a material for the surface appearance, for its high resistance against chemicals, or a myriad of other functions?

When designing with leather, it is important to keep the whole product in mind and choose the materials accordingly. Leather, by itself, can be very long-lasting. The likelihood of a consumer using the product for an extended amount of time is higher when the supporting materials, such as hardware, lining etc., are of similarly high quality. Many consumers will toss out a leather purse if the zipper is broken after three years, even if the leather itself would still be usable. While a reparability mindset of the consumer is desirable, the product composition is also essential to ensure a long lifespan of the leather product (see chapter 4.1 on design for longevity and reusability).

Transparency and Traceability

The trend towards more information downstream continues. This information might be communicated through, e.g. a label or certification. Building a dedicated supply chain is complicated, costly and location-dependent: Certain structures are needed to make it possible and feasible at all. The use of certified leather is therefore a viable option offered by the leather market. Chapter 3.6 on Labels and Indexes for Sustainable Products and Materials explores this topic more closely.

Intensified communication along the supply chain can also enhance information exchange. There is growing interest by brands with regards to labour and social standards, which manifests itself through an increasing number of inquiries and certification requirements passed upstream along the supply chain. Each step in the supply chain needs to probe their immediate and subsequent supplier on questions of societal relevance, e.g. animal welfare, environmental indicators or production circumstances. These questions do not have to originate from the end-users or the brands; each actor in the supply chain can and should assume responsibly and require answers about socially salient issues from their upstream supplier. Chapter 3.5 on Traceability dives deeper on technical possibilities of information exchange within a supply chain. With regards to sustainability, a designer can also look towards a more regionally focused production and procurement. Chapter 3.8 Supply Chains explores this topic further.

Material Selection as Key Driver for More Sustainable Leather Products

Summing-up selecting the "right" leather for a product is both an important and complex design step that requires comprehensive knowledge and rigorous material research. While all material choices will determine functional and aesthetic aspects of a product and affect to what extent it is sustainable, this applies in particular to leather.

Since there is no strict formula or simple rule that can be applied here, designers are recommended to take this design step serious by cooperating with experts from different fields and researching various material and construction options and their pros and cons before defining the specific type of leather. Systemically understanding the interrelations of certain types on hides, tanning agents, finishings and more on functional, aesthetic and overall sustainability attributes is of crucial importance for designing more sustainable products with regards to the product's entire life cycle.

4.4
Business Models for More Sustainable Leather

Ann-Cathrin Jöst, Karl Borgschulze, Simone Charlet

Leather is well known for its durable material features, maintainability and material longevity. However, the lifespan of leather products is often not fully utilised, which leads to a rapid disposal of the material or products of which the material is part of. To enhance the use of sustainable leather in a wide range of products and markets, business models can play an essential role.

Business Model Definitions

A business model describes how companies are doing business by looking at how resources are converted into economic value (Teece, 2010). They focus on the generation of revenues with a particular attention to a firms' "value chain and interaction with the industry's' value system," (Fisken and Rutherfold, 2002).

A sustainable business model also considers external costs of production such as a firm's indirect negative effects on people and the environment and instead views them as the firm's stakeholder [1] (Daly, 1990). Because of that, it creates new value to the firm's business. Examples for such a business model are companies that certify their products to ensure that production complies with environmental and social standards. These standards could relate to the use of sustainable chemicals in a product such as "Oeko-Tex", or products produced in regards to human rights, such as the chocolate brand "Toney Chocolonely."

While a sustainable business model takes external costs of production into account and adds new value to the business, it also faces limitations if the business model continues to depend on a finite amount of new resources. A circular business model therefore aims to capture the value of the product during and at the end of the production process as well as during the products lifetime. The aim of such a business model is to extend the life of a product for as long as possible in order to avoid the production of a new product. Also, it may also slow down production and thereby serves as enabler for more sustainable processes.

Leather and Business Models

Leather is used in a wide range of applications such as shoes, car seats, furniture, textiles and other accessories. The benefit of leather is its durability and quality, which make it usable for multiple years. Although the lifespan of leather could be extended by multiple years, this is not the case, as many products made of leather are only used for a short period of time. This particular applies to textile-based products, but also for other market segments such as furniture. In these market segments, many products are promoted for seasonal use and purchase, which makes consumers want to dispose existing products and purchase new ones more frequently. In addition, many of these products enter customer markets in a great design variety of colours, patterns, styles and shapes. This makes it difficult to reuse or adapt to new product designs or changes (Nieber, 2020).

Fig. 4.4.1 & 4.4.2)
Examples of seasonal promotion (WellingtonHomeTeam.com;)

Sustainable Business Models for Leather

Sustainable business models hereby play an essential role in selling different types of value related to leather to which customers feel attached to. A sustainable business model for leather, can look at how to design and promote leather products in such a way that they are kept by customers for multiple years. Because of that, material durability is important. For leather, this can mean to design and promote leather products in such a way that they are suitable for multiple market segments and appeal directly to a broader or different group of customers.

As design and business models go hand in hand, we have listed a mix of design choices that can promote a sustainable production and consumption system for leather designers and the consumer.

Products designed with a specific range of colours that customers can identify with over multiple seasons and occasions.

Some products are produced in a wide range of colours and patterns. Because

they are trend based or designed for a specific occasion, they are difficult to match with other products or seasonal changes. For this reason, they are more likely to be disposed after single or seasonal use. Therefore, it is encouraged to use natural, hearty tones, authentic tones, joyful bright colours that complement neutral tones, colours that feel clean, restorative and energising ([3]Stahl, 2021). In doing so, custom made designs or feeling based designs can help customers maintain a certain feeling (i.e. warmth and energy) and keep the product longer.

More specifically, seasonless designs (see chapter on methods 6.1) can place a greater emphasis on the durability of these products and therefore create greater interest in the quality and durability of the product. In addition, seasonless design provides an opportunity for businesses to produce and sell at a higher value, as customers can face less pressure to buy into new designs for the next seasons. This may also encourage customers to purchase leather products with a higher price.

Products that are genderless

There has been growing awareness on how gender-based clothing depicts gender-based stereotypes. "Infant girls are swaddled in pink. Boys in blue. Girls wear skirts. Boys pants. Clothes make the man. Who wears the pants, signals dominance." [2] In doing so, industries may assign a certain gender-stereotype that does not fully align with the indentity of the individual.

Besides imposing a specific gender-identity onto the consumer, these products can be difficult to reuse (e.g. children's shoes being passed on to younger siblings), but also more materials are needed, which can make the processing, maintenance and repair of leather goods more complex.

Genderless or more specific "gender-neutral" designed products therefore have the potential to promote a product-value based connection between consumers and the features of leather products, as opposed to an image sold. Such a product may also feel more empowering to the customer as they are more likely to buy the product because of their intrinsic interests instead of the depicted stereotype.

Products in which the functionality of it is the primary sales objective.

In the past, products were used to protect us from environmental hazards. Now, many products are promoted in such a way that their functionality is limited. A business model that focuses on material longevity could take a product's versatility and functionality into account by promoting leather goods for a specific purpose, e.g. "suitable as protective gear or for general use, as leather outperforms other materials in terms of quality and durability." Doing so, this also allows the customer to buy into the function of the product.

Products that change

On the contrary, not all customers may want to buy into "limited" design-choices. They may want products that set them apart from other customers to directly highlight their taste and individuality [4]. For customers to keep their product for as long as possible, products could be designed in such a way that shapes and colors are changeable or some parts of the products could be adjusted over time. Could we, for instance, design shoes to be redyed? Or could we print our own design on shoes that are removable?

Fig. 4.4.3) Inspiration by OurChoice-Fashion in collaboration with Sustainable Fashion Week US (Photo: OUR CHOICE & Calder McCay, 2021)

Circular Business Models for Leather

While leather is a durable material, the entire product system of which leather is part of may not be. In addition, leather can also be processed in a way that makes it difficult to maintain or repair. An example of such a product could be a shoe that is difficult to disassemble and repair because it consists of more than 40 pieces, or a leather couch with a broken leg. If materials are not easily repairable, there is a greater incentive for customers to dispose the entire product and buy a new one. Therefore, a circular business model can help customers keep their products by focusing on different types of repair or maintenance strategies that are financially viable for the customer and the business.

Types of circular business models

Many circular business models differ between ownership and non-ownership models. Products in which the ownership of the product is kept by the company are also known as "Use-Oriented Product-Service-Systems" (PSS) and "Result-Oriented Product-Service-Systems" (RSS). PSS-business models are geared towards the sale of the product function. This can be done through leasing, subscription or renting, where the product remains in the ownership of the PSS provider. Products with RSS-oriented business models are geared towards the sale of a result by offering a pure service where no predetermined product is involved [5].

Then there are also non-ownership business models. In these models, firms may offer maintenance services or discount-based take-back systems [6] to customers. In other non-ownership based models, customers themselves are engaged in the re-sale of their goods for example on secondhand platforms (peer2peer).

Case-Studies and Impulses for Circular Business Models

While there are many business model options, each business model is product and market dependent. Below are a number of business model case studies and impulses that follow circular principles:

Ownership-based business models

Currently, a wide range of leather-based products are used, such as furniture, accessories or fashion goods. As companies often do not maintain ownership, these products are usually not designed to last a long time. Producing goods that last can become profitable if companies remain the owner of a product, e.g. by renting out, offering subscription services or by leasing a product.

Use-Oriented Product-Service-Systems

Rental

Some products are often used by consumers for a short period of time. One such example is a horse saddle or sport equipment such as ice-skates. As opposed to buying them, companies can offer rental services for these products. Part of these services can be product maintenance and repair that ensure consumer satisfaction throughout the time of use. Similar to renting an apartment, a specific quality and service standard can be expected. In turn, the consumer has the responsibility over the proper use of the product, i.e. when renting leather based furniture or in our case ice-skates, the consumer must follow the appropriate care instructions.

Subscription

Sometimes consumer's tastes or requirements for a product, so they may want to discard it although the quality is still good. Meanwhile, the same product may be suitable for a different consumer with similar needs or desires for it. To keep products in the company's system, companies can offer subscription services to their customers, in which customers only pay a service fee for product maintenance. An example is a subscription service for children leather shoes over multiple years.

Leasing

Sometimes buying a product is financially very challenging. Therefore, leasing a product to a consumer can be an option. Once the leasing period is over, the consumer can decide whether to buy the product outright or lease a different product. In both cases, high quality is important. In addition, product services are often offered in leasing .

Service-Oriented Product-Service-System

Many products are owned by customers, but their use-time often varies. A phone is used almost every hour, while a drilling machine may only be used for a few hours during its entire lifetime. The difference between both is the service that each product provides. The service of a drilling machine is, amongst other things, to drill a hole in the wall. This differs from a phone, which provides multiple services, as it is being directly used by the consumer. These concepts can also be applied to a range of leather products. Some products are used frequently like a chair, while other products, like a horse saddle, may only be used on specific occasions and for a specific purpose, such as "feeling comfortable, while riding".

For leather products, this means thinking about whether products can be offered in such a way that the service of the product is being sold. For example, rather than selling leather seats to the automotive industry, features like a high comfort and satisfaction, water-resistance- or breathability and so on can be sold instead. Can you think of more leather or leather based product features that can be sold as a result- service?

Non-Ownership-based business models

Then there are also non-ownership-based business models where circular design plays an important role.

The start up "Our Choice Circular Fashion", specialises in modular leather shoes and has integrated a take-back system and maintenance service into its business logic [7]. Customers pay for a pair of shoes, return them and receive an upgrade depending on which part of the product needs repair. Likewise, the company mudjeans takes back old jeans for a discount and recycles them into new jeans [8].

Vinted, a second-hand platform for mostly textiles and other products, operates as a peer2peer online business and allows the selling and buying of pre-owned products. Vinted receives a growing service fee that depends on the resold item once it has been sold. Its users buy and sell their products independently. The company "TheRealReal", which specialises in buying and selling of pre-owned, high-quality textiles, has set up its own product take-back and resell service online and offline. In doing so, it can classify the product quality into three categories of returned items and pay sellers accordingly.

IKEA, in turn, is experimenting with consumers returning their products for a discount and reselling them in their shops [9]. IKEA also realised that many of its products are being resold on second-hand platforms and therefore aims to develope sustainable products where broken parts can be replaced to provide incentives for new consumers to buy and resell IKEA products at a higher price.

On a larger scale, Consulting Service International (CSI) had implemented an business model targeting the EU and Pakistan that focuses on a circular system for hotel bedding. In this business model, old bed sheets are purchased, washed, recycled and turned into new products. "After consumers have finished using their product, it will be collected and sorted within the EU. Once it is sorted, it can be shredded into fibre in Pakistan, where it can also be used for manufacturing new products for import into the EU " (CSI, 2021). Looking outside the domestic or European market for recycling and circularity solutions can be a realistic option for circular business models in the leather industry as well.

Fig. 4.4.5, above)
Hotel bed based on a circular business model
(Source: CSI Ltd.)

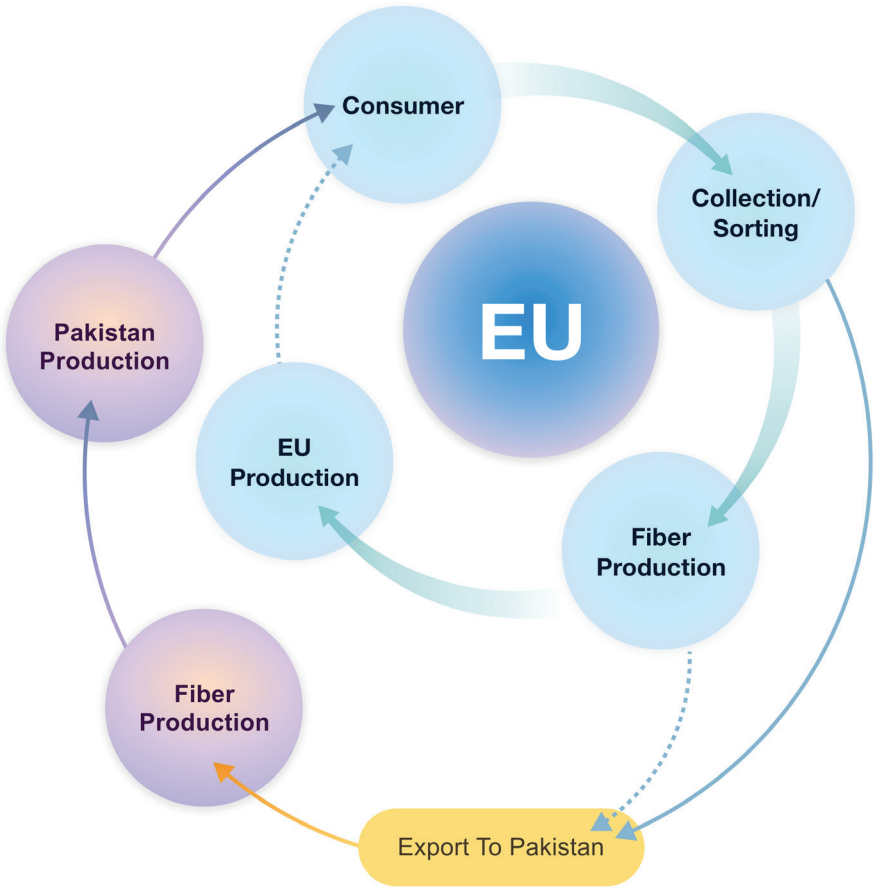

Fig. 4.4.6,) Simplified illustration of circular business model for hotel bed. (Source: CSI Ltd.)

Choosing the Right Business Model

Business models are versatile, and this also applies to the ability of a business to change its business logic. To start off, it is recommended to identify what value is being permanently destroyed in production, what value is missing, and based on both, how new value creation opportunities could be created in relation to leather and design. A few inputs are provided in the table below.

1. Current value destroyed	2. Current value missed	3. Value opportunities
How does your product or service contribute to permanent environmental or social damage, i.e. air and water pollution, contribution to landfills, sickness of producers and/or consumers? How will that affect your business in the long term?	Are there waste streams that add to existing production or disposal costs? Is there a customer group that is unable to purchase your product or service, i.e. because the buying price is too high? How many products are left at the end of the season that go to waste?	Could your waste streams be turned into profits either by creating new products, taking back old ones or by turning waste into energy? Could you make sustainable products accessible by offering rental or leasing schemes to a wide range of customers? Could you design products in such a way that they can re-enter your sales system over multiple years? Can sustainable processes simply ensure that your business remains operational?

Table 4.4.1) Choosing the right type of business model

A few Things to Consider Before Going Sustainable and Circular

Supply Chain

Nowadays, many supply chains are not decentralised, but rather complex and intertwined on a global scale. This makesthe implementation of take-back systems on a large scale quite difficult. There could be opportunities if new partnerships and decentralised businesses can be established. These partnerships could help create more regional markets for which reverse logistics and take-back systems are feasible.

Returned quantity

Taking back products is beneficial. On the contrary, companies rely on a fixed quantity of returned good. Without this fixed quantity and predictability, it is difficult to plan and account for the future. Therefore, it is desirable for different industries to join and work together to receive a sufficient quantity of returned goods in order to do profitable business.

Quality

Many of the products taken back may be of lower quality. Because of that, reusing and recycling them makes it difficult. Returned items should therefore be of high quality. Otherwise, they will be discarded. There are opportunities here if customers get a discount or money back if the functionality and, to a certain degree, the quality of the product is maintained. This could be particular appealing for products with a higher price category such as furniture.

Image

The image of leather is very different and so is the interest in purchasing the material. Therefore, a business model also needs to take into account the particular market segment for which the product is used, i.e. luxury market or markets in a lower pricing segment. Thus, a business model could also think about how higher priced products could be accessible for customers with a lower budget such as through rental or subscription services.

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4.5
Marketing and Communication

Ann-Cathrin Jöst, Karl Borgschulze, Simone Charlet

Leather and Authentic Communication

In the context of leather and leather products, marketing and communication are perceived as more complex than other topics, because individual moral decisions and lifestyles influence perception and discourse. That can create positive pressure to actually and authentically pay attention to animal welfare, the processes involved and social standards, since a stronger group of critics can be expected here. Because of existing challenges, but also opportunities implied in the production processes, communication for sustainable leather should focus on the authenticity of the product and its production.

Authentic communication is important because criticism towards the sustainability of leather is growing and with it consumer interests for alternatives such as "vegan leather" or purely synthetic leather. These alternatives do not have the same properties as real leather and therefore differ in their material features. Thus, the design and the durability of the (synthetic) leather can also vary.

While there is not "the best" material for every product, there is a material that is most suitable for a specific product feature. For certain goods, such as shoes, some furniture and accessories, where strength and longevity are important buying and selling points, real leather is very suitable. This differs to synthetic alternatives that may not be able to meet these material criteria but are communicated as such. Because of the growing misconception between leather, its benefits, disadvantages and synthetic competitors, the true value of (sustainable) leather needs to be communicated and marketed.

Changing Perception of Leather

Throughout history (see chapter 3.7), leather has had significant meaning. Unlike today, leather was mainly used and promoted for its particular material features. Nowadays, leather is still promoted, but mostly for the entire product of which leather is a part of. In addition, many materials are mixed to

achieve specific product features, such as the feeling of softness when lying on a pillow with a leather cover. However, the feeling of softness when lying on a pillow is not primarily achieved due of the leather cover but due to the pillow content. Since the feeling of softness may be the key feature the customer is looking for, the particular type of leather may appear less important to the customer.

This differs from the past where products were particularly bought because of leather and less likely for the multiple functions the product offered. A side effect is that the true value of leather is frequently under-communicated, all the more the look of it that can be achieved through synthetic applications is communicated. Promoting genuine leather and leather-based goods could therefore tie in with historical concepts in which leather was used and purchased for its features and unique charm. These values could be reintegrated into design, marketing and communication strategies.

Fig. 4.5.1)
https://www.libertyleather-goods.com/history-of-leather/

Communication Should Focus on Material Features and the Value Communicated in Specific Market Segments

Today, leather is used in various types of bags and cases, shoes, trousers, jackets, accessories like hats, belts and jewellery, as well as furniture and seating. Among its key qualities is its protective durability, which is why it is still a preferred material choice for motorbike gear. Leather is also perceived as high quality, functional and comfortable, especially for footwear and clothing because of its ability to adapt to the wearer's individual anatomy over time, such as in shoes.

Besides direct product features, leather goods still fill unique market segments. An example is that leather has the image of being a luxury good and finds unique applications in formal wear, shoes, watch bands, furniture and car seats. Here, quality in an important selling point and should be promoted. A brand could communicate the value of truly (sustainable) leather, how to maintain and care for it and how leather competes with other alternatives that are less durable.

Besides globally operating brands, there are also smaller market segments that can benefit from authentic product communication. For example, Small-Medium-Enterprises (SMEs), that specialise in the sales of traditional crafts can benefit from communicating their products true value, connecting the consumer to the origin and processes of the product. To do so in a authentic way, enterprises are encouraged to make their marketing messages clear:

- Why are we using leather?
- Where does the material come from?
- Where are the tanneries?
- How do they work?
- Is my product regional or do we fly the cow/leather/product several times around the world?
- Are the people who tan my leather well paid and safe?
- How does my product support sustainable development (in the region)?

Communication and Marketing Need to be Authentic and Sincere

Multiple labels and certifications schemes exist that aim to illustrate the extent to which a product has been produced sustainably. While these efforts are essential, they can also be overwhelming or misleading if companies do not fully clarify what they mean by sustainability. There could also be too many labels and certificates, making it difficult for customers to understand the true value being communicated, or the value being communicated is not honest, leading customers to believe a company's greenwashing.

For example, leather can conflict with modern notions and approaches of sustainability. There is a conception that organic materials or materials processed organically are sustainable, yet the tanning of leather uses chemicals that can have detrimental effects on the environment. Brands use the term "vegetable tanning" in marketing to indicate the sustainability of the production process. This can mislead consumers into thinking that vegetable tanning is a clean and sustainable process. While this process eliminates the risk of toxic chemicals ending up in waterways and harming workers, it can contribute to deforestation as trees are stripped of their bark with negative effects on their health.

To communicate sustainable efforts and authenticity in the leather industry, the following strategies are recommended:

- Focus on building trust. Customers tend to trust reputable certificates, labels and standards (ÖKOTEX, DIN...).
- Include agreements and communicate them. International agreements and requirements (Global SDGs, EU Green Deal..) have an impact on the leather industry. Their concrete implementation and the efforts to achieve them should be made visible.
- Show product developments in your communication. Long-life and modular products can create the conditions for multiple use and circularity.
- Illustrate how your products support the creation of sustainable business models. While we do not fully support synthetic alternatives to leather, some consumers favor them. Therefore, you may want to establish a 2-way business model (natural leather and non-leather alternatives) in partnerships and corporations.
- Involve your customers in your communication by including their product requirements, expectations and experiences in the strategy.

Case study - "Shoes suck" campaign by Reformation

Because there has been criticism towards leather, it is suggested that marketing should focus on the authenticity of a product and the brand itself. A brand should make clear what efforts it is making to integrate sustainability into its strategy. The company Reformation (see fig. 4.5.3) illustrates that its products aim to meet the highest sustainability standards that exist for leather while being honest that their product still has an environmental footprint. With the campaign "Shoes suck", which includes a series of short video clips, the detrimental effect of leather production on the environment is highlighted. The inherent challenges of sustainable leather are communicated clearly and concisely to consumers.

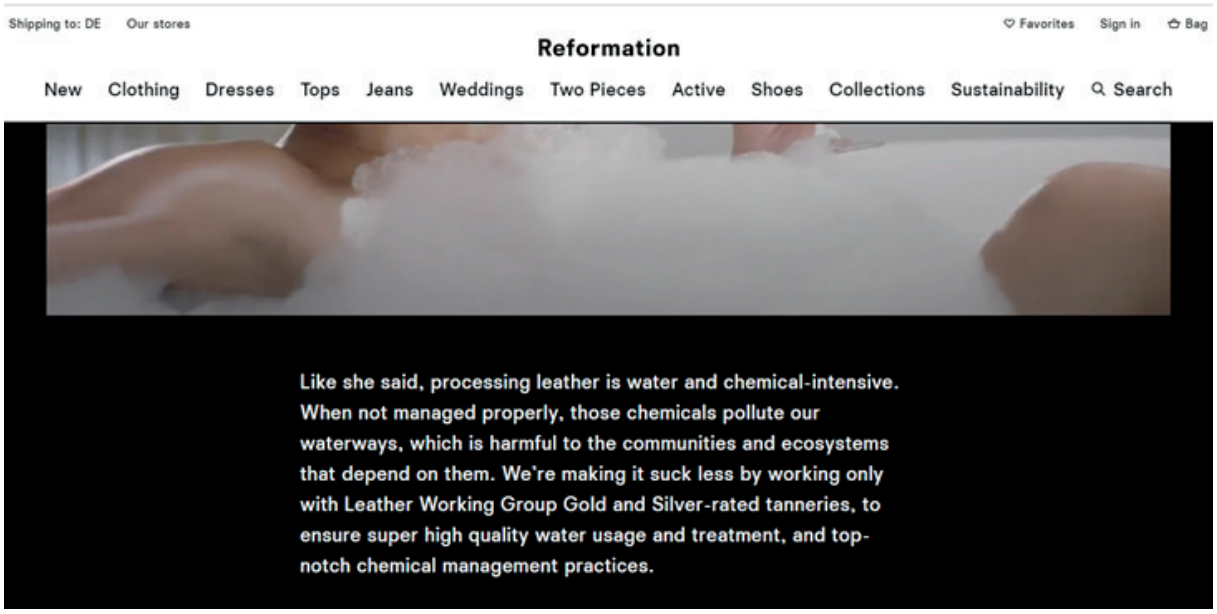

Fig. 4.5.3)
Marketing of the company Reformation

Communication and Marketing Can also be Used to Promote Sustainable Behaviour

Often high quality leather is related to higher priced product segments and is therefore less accessible to a wide range of customers. This makes the purchase and production of lower quality products more appealing. However, leather is very durable and resistant to environmental stressors and can therefore be kept longer in a good condition. In comparison, synthetic alternatives are not as durable and take longer to decompose.

Brands can encourage a wide range of customers to buy leather by communicating its values. This can be done by marketing business models that center around product rental, repair and also the possibility of upcycling and recycling (see chapter 4.2 on design for recyclability & 4.4 on business models).

Communication should go hand in hand with the business models and therefore also consider the care, repair and maintenance of a product. Proper care instruction, product maintenance or even repair directions can be provided via various channels. These could be product care manuals that come with the product, or open source tutorials that are broadcasted online, in social media channels or provided to specific repair shops.

The automotive company "Sono Motors" follows such a scheme and has developed a three-stage repair system that operates via open source:

- 1. Do it yourself. Spare parts can be installed in the vehicle by the customers themselves without any skills or experiences needed.
- 2. The disclosure of the product manual contains an extensive network of independent repair and assembly shops.

- 3. For all more complex repairs, Sono Motors cooperates with a well-known service provider from Europe.

Lastly, brands may also communicate emotional durability to support the material reuse and longevity (see chapter 4.1). Products are often kept longer if there is an emotional bond between the owner and the product. One such example is a leather armchair that someone inherited from their parents. With that in mind an in relation to leather, an emotional bond could be established by adding a storyline to the product that is true and authentic. "Where does it come from? Who are the people who produce it? Is there a story they can tell? What value am I communicating with my product? Is my focus on healthy processing or even on the people producing and consuming it? What is their story?"

Marketing for Sustainable Leather Needs to be Adjusted to Different Customer Segments

There is a growing interest of millennials, generation Z and X to purchase more sustainable materials. These generations are also the generation most active on social media platforms like Facebook, Instagram and Tiktok, where social media influencers play an active role in forming and shaping consumer behaviour. These are also the platforms where many products are marketed to be criticised and greenwashed.

As leather is facing growing criticism and competition from non-leather alternatives, these platforms could be used in an educated format. In doing so, communication and marketing strategies can focus on educating people about leather, its sustainability, its criticism, but also the opportunities leather offers for the Do-It-Yourself (DIY) market. These platforms also offer an opportunity for engagement between brands and customers to build a closer relationship. Other formats can also be used to communicate the value of leather, for example in magazines or shops that often utilize leather. These can also, for instance, highlight business models for which leather is well suited, such as renting products instead of justing them (see chapter 4.4 on business models).

Transparency and Traceability Support Effective Consumer Communication

The authors believe it is important to communicate honestly what the entire material is made of and where it originates from (see chapter 3.5 on transparency). Transparency can help clarify the origin of leather and help consumers make purchasing decisions that align with their views on sustainability values. Transparency may also help to illustrate different aspects of leather and

sustainability, e.g. not only where the hide originates from, but also how different workers can benefit from it (i.e. livelihood opportunities, human rights support, SDG compliance).

For a design, this could mean integrating a QR code in the product that allows customers to quickly follow the product's history. For marketing and communication, this also means showing images and interviews with factory workers of different stages of the supplychain. Also, these should be authentic and not focus on a division between "workers from poor and rich countries", but rather on employees and beneficiaries inside and outside the supply chain.

Case study – Innovative communication concept of the Partnership for Compliance

Leather inevitably comes with communication challenges. When developing communication strategies, it is important to be aware of the product's strengths and weaknesses in relation to leather. Brands need to be clear about their reasons for using leather in their products, stand by their choices and communicate them clearly to consumers. As sustainability becomes a basic requirement of any product, the concept of sustainability itself is also constantly evolving as we learn more from science and experience. This may lead to innovative and sustainable products, but communicating the complex concept behind them can be difficult. In a time of information overload and short attention spans, the ability to quickly and concisely communicate complex information regarding sustainability is more important than ever.

Example: Deerskin sneaker

With the Partnership for Compliance (PFC), CSI implements innovative communication concepts for products with a sustainable story. These concepts highlight three focus areas – sustainability, innovation and communication. The Products are sustainable and compliant, integrate innovation and come with necessary data and material to tell their unique story. While not aimed directly at consumers, PFC enables brands and retailers to tell the product's story and explain its sustainability concept in an accessible way. Besides explaining why the materials where chosen and what makes them a sustainable choice, sustainability is quantified with easily understandable indicators such as carbon and water footprints. As global supply chains are often intransparent, providing information, photos and videos from the production also helps make the complex concept tangible.

The deerskin sneaker developed by Partnership for Compliance/CSI was designed with sustainability and innovation in mind. The concept behind it is complex, but can be precisely communicated using data and storytelling.

5

Design Tools & Method Overview

Based on the knowledge and insights collected so far, chapter 5 aims at summarising the methods, approaches and tools of the previous chapter to easily refer to them or revisit them during design phases. The "Leather Product Design Canvas for Sustainable Development" in chapter 5.2 represents a methodology in itself that draws links between some of the topics and methods illustrated before by providing a systemic overview.

5.1
List of Design Methods

Jonas Rehn-Groenendijk

This chapter comprises the design methods and approaches that have been mentioned and integrated in the previous chapters. Some of the methodes collected here are more elaborated techniques of the approaches used in the chapters or case studies above.

Design Methods

Neutral aesthetics / seasonless design

Using rather neutral or less extravagant styles might lead to leather products that are fashionable beyond one season, possibly extending emotional durability and product lifetime. As usual, this has to be in line with the overall design strategy, fitting to the target group and product context.

Design approach: Design for Longevity
Design aspect: formal-aestheic features, conceptual features

Chapter 4.1, Design for Longevity
Chapter 4.4, Sustainable Business Models for Leather (p.172)

Linking products to memories and nostalgia

Products that relate to certain moments or topics might increase emotional durability and product attachment. From a design point of view, this links conceptual and aesthetic design with marketing and business models. For

instance, a luxurious watch brand once stated in an advertisement campaign that its products are not bought for oneself but to be passed on to the next generation. In order for this campaign to be effective the product design needs to fulfill a number of requirements. Firstly, the product needs to be of a certain quality in order to last long enough to be passed on. From an aesthetic point of view, this has to be emphasised by a style that is both "timeless" as well as luxurious in the sense that this product is worth being passed on. Of course, this is only one out of many approaches to how products can be linked to memories and nostalgia.

Design approach: Design for Longevity
Design aspect: conceptual features

Chapter 3.7, The History and Culture of Leather

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Products that are genderless

Lots of gender sterotypes are embedded in the marketing of a product and because of that the design. Lets be empowering and change that .

Design approach: Design for Reuse
Design aspect: conceptual features, formal-aesthetic features

Chapter 4.4, Sustainable Business Models for Leather (S.173)

//

Design for Recycability

Products should fit into the normal circular economy. Means it has to be easy to put into its individual components, and this components should fit into the recycables collections.

The components should better sewed than glued over the whole surface. Bigger pieces are better than smaller ones. If you want to reinforce material, then use components that fit together or do not interfere with each other during recycling (for example leather together with leather-fibre-board).

Chapter 4.2, Design for Recyclability

//

Products that can change

Designing products in such a way that shapes, colours and parts are adjustable over time. Could products change their colour?

Design approach: Design for Longevity
Design aspect: conceptual features

Chapter 4.1, Design for Longevity
Chapter 4.4, Sustainable Business Models for Leather (S.174)

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Create confidence in a product by transparency

If manufacturers, sales personel and consumers are asked to take resonsibility they need full or at least widely access to information about the production process and the ingrediences and substances in the material they deal with. An example for such a strategy might be ecopell.

Chapter 3.5, Implications for design

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Products in which the functionality of it is the primary sales objective.

What particular quality has what type of leather and for what product is it most suitable?

Design approach: Design for Process Optimisation
Design aspect: technical features, material selection

Chapter 4.3, Material Selection

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Products that are designed with a specific range of colors that customers can identify with over multiple seasons and occasions.

What type of colours are suitable for multiple season or work well with other designs? What feeling should what type of color evoke?

Design approach: Design for Longevity
Design aspect: aesthetic features
Chapter 4.1, Design for Longevity

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Products that are compliant with current and future regulation
Having a holistic approach in designing to ensure that products comply with current and future regulation and not only look how to, for example, substitute chemical x with chemical y.

Chapter 3.4, Implications for design, with a focus on chemicals (p. 94)

//

Products that are traceable
Besides just designing the product itself, also consider designing a product information framework which helps consumers to gain more transparency through better traceability.

Chapter 3.5, Conclusion: How Traceability relates to Design (Guidelines) (p.106)

//

Products with a required or desired label
Designing products in a way so that these products are able to acquire a required or desired label

Chapter 3.6, Labels and Indexes (p.109)

//

Linking products to ancient production techniques for unique and natural features
Designing products that use ancient production techniques that can give the final product a unique feature, like raised edges through wet moulding for example. Thus, consumers may increase their emotional attachment to the product, as it seems 'rich in history'

Chapter 3.7, Intriguing leather processing techniques (p.117)

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Products designed to be disassembled

Designing a product in a way so that spare parts can be replaced and the longevity of the product can be increased

Chapter 4.1, Leather and design techniques (p.144)

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Products designed to last a lifetime

Products can also be designed in such a way that a product lasts a long time without the need for repairs or the like

Chapter 4.1, Leather and design techniques (p.146)

//

Products designed with reduced complexity

Designing products that only contain one durable material for example, and increasing its longevity

Chapter 4.1, Leather and design techniques (p.146)

//

Products that are designed for Recyclability

Products should fit into the normal circular economy. Means it has to be easy to put into its individual components, and this components should fit into the recycables collections. The components should better sewed than glued over the whole surface. Bigger pieces are better than smaller ones. If you want to reinforce material, then use components that fit together or do not interfere with each other du- ring recycling (for example leather together with leather-fibre-board).

Chapter 4.2, Design for Recyclability (S.151)

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Products in which the functionality of it is the primary sales objective
What particular quality has what type of leather and for what product is it most suitable?

Chapter 4.4, Sustainable Business Models for Leather (S.173)

Products that are designed with a specific range of colours that customers can identify with over multiple seasons and occasions
Designing products custom made or feeling based, with energising colours for example. What type of colours are suitable for multiple season or work well with other designs? What feeling should what type of color evoke?

Chapter 4.4, Sustainable Business Models for Leather (S.172)

Products that can change
Designing products in such a way that shapes, colours and parts are adjustable over time. Could products change their colour?

Chapter 4.4, Sustainable Business Models for Leather (S.174)

5.2
Leather Product Design Canvas

Jonas Rehn-Groenendijk

Abstract

Leather as an ancient material features characteristics and properties that in many cases relate to sustainability by default (e.g. durability, repairability and aesthetically pleasing ageing). At the same time, in contrast, highly complex and non-transparent leather supply chains and increasing func-tional and aesthetic demands lead to problematic conditions regarding, for instance, the leather chemistry. Because of the technical and structural complexities, it is hardly possible to provide a list of design aspects that lead to more sustainable leather products by default. The herewith presented „Leather Product Design Canvas", aims to support the design process of leather products in favour of sustainable development by offering an over-view of critical aspects and helpful impulse questions to guide the design process in an iterative and explorative manner. Based on a transdisciplinary research project, this canvas has been developed together with representa-tives from organisations along the leather value chains, as well as NGOs, as part of the project. It draws links between general design aspects and ap-proaches for sustainable development that relate specifically to leather products. From this perspective, innovative systemic solutions as well as business models (i.e. product-as-a-service offerings) can be developed that go beyond current approaches of leather product design.

Keywords:
design framework; leather product design; design for sustainable develop-ment; systems innovation; transdisciplinarity

Background

Aiming for More Sustainable Leather Products

Sustainable development, as operationalised by the United Nations' Agenda 2030 [1], is a complex and multi-faceted issue. Many of the challenges associated with sustainable development are often referred to as a (super) wicked problem [2]. As outlined by Levin et al. [3], super wicked problems do not only consist of a number of complex and interdependent challenges. Moreover, solutions to one problem might create an-other problem.

The same applies to the leather industry and leather chemistry in general as well as to the design of more sustainable leather products. The global leather supply chains are complex, diffuse and interdependent systems. Many different production steps across continents, carried out by different companies, are required before a consumer product reaches the place where it is sold. As with most other industries, throughout this process, enormous amounts of chemi-cals are applied, which can be harmful to humans and the environment [4], energy is used and CO2 is emitted. For a leather product to be declared "sus-tainable" to some extent, a systemic perspective is required.

As illustrated by Ceschin and Gaziulusoy [5], current approaches in design for sustainable development go beyond mere improvements in technical or other specifications of products and focus on broader systems of which products are a part. As a result, design paradigms and strategies such as product-service-systems and systemic design [6, 7] extent the scope of traditional industrial design.

Ceschin and Gaziulusoy [5] propose an evolutionary framework of design paradigms and methodologies that aim a fostering sustainable development. Referring to a recent review on sustainability-oriented innovations by Adams et al. [8] they identify a tendency towards both more systemic and more people-oriented approaches in design for sustainable development. In line with research in the context of system innovation and transition [9, 10], products and are not only embedded in wider product-ecosystems but are part of sociotechnical systems [11]. Steps towards sustainable development therefore require a systemic perspective that does not simply aim at improving single products but at gradually transforming industries and supply chains.

As mentioned before, the 17 sustainable development goals and the included 169 targets proposed by the United Nations offers a structured and effective framework for design strategies to foster sustainable development. Although their main purpose was not to inform design processes, many SDGs refer to aspects that are directly linked to the design of products and services while maintaining a systemic perspective that acknowledges interdependencies and relations between different factors.

This applies, in particular, with regards to the 11 targets summarised by SDG 12 "Ensure sustainable consumption and production patterns". Designing more sustainable leather products involves a number of aspects, approaches and perspectives that relate to various aspects of sustainable development. Designers and others involved in the development process of new leather products often face the difficulty gaining an oversight of these issues and developing a systems perspective to create more sustain-able products. While not all of these topics necessarily need to apply to each individual project or product, gaining an oversight and considering their role in the design pro-cess is crucial to making an informed design decision. This requires an interdisciplinary approach that avoids "silo thinking", simplistic solutions and rebound effects (negative side effects caused by a singular improvement).

As a means to quickly cover all these topics in a first easy-to-access manner, an interdisciplinary group of experts, including, inter alia, design researchers, chemists, leather experts, developed the following Leather Product Design Canvas. It is based on the concept of the „Business Model Canvas" (BMC) proposed by Osterwalder in 2005 and refined since then [12]. According to van Boeijen and colleagues the canvas „as a tool can be used in various stages of the development process [...] The Business Model Canvas serves as a checklist to generate business ideas; it also structures, discusses, and evaluates these ideas on a conceptual level" [13].

The Leather Product Design Canvas [14] makes use of a similarly conceptual and graphical structure while comprising more refined elements and specific impulse questions to raise awareness and guide design processes. It aims at supporting the product development and design process of leather products to create more sustainable products. This shall be achieved by providing a quick and multi-perspective over-view of relevant topics and considerations. One reason for this approach is that in many cases the designers of leather prod-ucts such as shoes or bags do not necessarily need to be leather experts. Even interdisciplinary design teams might not include experts that understand both issues of sustainable development and material properties of this versatile material. Moreover, the complexity of the material leather and its various types of application would usually require a number of different experts to cover the most relevant topics related to sustainable development in order to identify possible rebound effects and systemic interdependencies of certain design decisions. The herewith presented canvas does by no means compensate for these expertise but aims at empowering design teams to take first steps to-wards more sustainable leather products based on a broadened scope while identifying knowledge gaps or the need for specific experts to be consulted or included in the design team.

One of the key challenges in designing more sustainable products is to improve specific aspects of a product or its ecosystem while avoiding purely "symbolic" actions, managing potential target conflicts and without creating negative side effects regarding another aspect. Therefore, this canvas illustrates relevant elements at one glance, raising awareness for their interdependencies. The

Canvas, however, does not replace thorough analysis of these aspects, but rather aims at providing a multi-perspective overview and explorative impulse to foster more sustainable approaches. In line with this, the canvas is not a scientific analysis tool that results in more sustainable leather products by default. Its main function is to illustrate a comprehensive overview that informs and guides the design process through structure and impulse questions. In this way, otherwise potentially neglected issues such as pre- or post-consumer recyclability or sourcing is put into the centre of awareness.

History of Origins

This canvas is a first spin-off from the project "handbook of leather desgn for sustainable development" [15] as part of a transdisciplinary research project at Darmstadt University of Applied Sciences aiming for more sustainable chemis-try in the leather supply chains [16]. It is part of a comprehensive transforma-tive research project aiming for system innovation for sustainable development funded by the Federal Ministry of Education and Research - BMBF and the State of Hesse (First funding period until 31.12.2022). The term "system innova-tion" refers to technical, social and organisational innovation, underpinned by an institutional framework, that is necessary to achieve transformation towards sustainable development. Institution, in this con-text, refers to all formal and informal instructions such as legal rules, company policies, habitual patterns of designers etc. [17].

Both the overall project and its "subprojects" are carried out by transdisciplinary teams including experts such as scientists from different fields (Law, Business, Psychology, Design, Chemistry and Engineering), representatives along the leather supply chains (chemicals, tanning companies, processing industry, brands, etc.) and other stakeholders such as NGOs and political consultants. Since the year 2018 the project team conducted a comprehensive participatory process that includes a six-month scenario process in which representatives from the leather supply chains co-created scenarios for the global leather industry for the year 2035. Based on this process a "theory of change" has been developed that aims at structuring a multi-stakeholder process towards a more sustainable leather chemistry by 2035 [18]. In September 2020, the project started four multi-stakeholder implementation projects aiming at specific top-ics outlined in the theory of change that promise the greatest lev-erage in terms of the envisaged transformation towards more sustainable chemistry [19]. These subprojects focus on (a.) IT tools and governance for traceability of chemicals along supply chains, (b.) chemical and process innovations, (c) handbook of leather design for sustainable development and (d.) harmonisation of standards for "more sustainable leather chemistry".

In subproject (c) focusing on a handbook of leather design for sustainable development representatives along the global leather supply chains and other stakehold-ers engaged in a number of workshops to draft the outline of the handbook and collected relevant issues and references. After this, these

actors formed sub-groups of co-authors that started a co-creative writing process of each chapter defined in the outline. Mean-while, insights from these workshops and the writing process where systematically consolidated and formed the basis of the herewith proposed canvas. In an iterative process, the interdisciplinary univer-sity team elaborated on these insights and formed key categories to be ad-dressed by this canvas. First versions of the leather product design canvas where the reviewed by the members of the subproject during an online work-shop.

Concept and Layout of the Leather Product Design Canvas

As a result of the before mentioned iterative transdisciplinary research and co-creation process the Leather Product Design Canvas has been created as an open access PDF that can be used by design teams, researchers as well as students and teachers. It has been firstly presented at the XXXVI IULTCS Con-gress in Addis Ababa November 3 to 5, 2021.

Structure and Format

Analogous to the "Business Model Canvas" mentioned above the Leather Product Design Canvas is a digital poster designed to be printed out in formats from A3 to A1 to be used individually or during workshops.

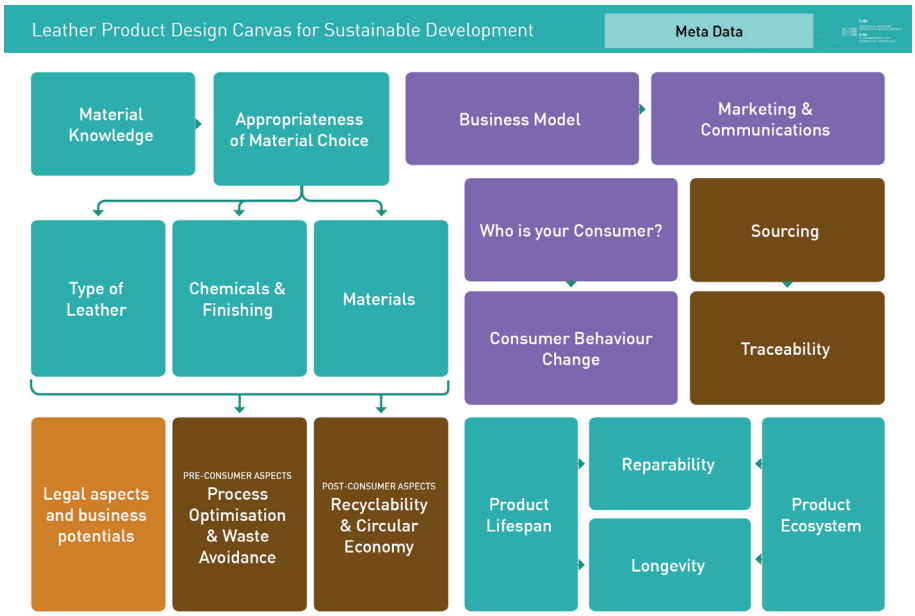

Fig. 5.2.1) Overall layout of the Leather Product Design Canvas

The Canvas covers four overarching themes divided into 18 boxes each resem-bling one relevant aspect of the leather product at hand with regards to sus-tainable development (Fig. 5.2.1).

Green Boxes - Technical Aspects

The green boxes in Fig. 1 refer to aspects that could be summarised as rather technical such as material properties, chemicals used or the technical aspects that allow or inhibit reparability.

In some cases, **Material Knowledge** could be seen as the starting point for (re-)design processes and product improvements. A comprehensive and state-of-the-art knowledge about materials that are available and relevant to the project at hand is crucial to ideate and evaluate design options. With regards to sus-tainable business structures and ecosystems supply and knowledge about sources relates to this category.

Based on this, **Appropriateness of Material Choice** is choosing the right material to the specific product. In some cases, a seemingly less sustainable material might be the better choice due to requirements on physical robustness leading to an overall more sustainable product. A systems perspective is required to understand the complexity of appropriateness in this regard.

Choosing the "right" material relates to three other boxes in this Canvas: Since not all **Types of Leather** have the same physical and aesthetical properties, it is of crucial importance to consciously decide on type of tanning process, tanning agent but also type of animal origin. Leather made from deer hides or cow hides might be more robust than sheep leather. On the other hand, the latter might offer advantages in terms of weight when used on a light summer jacket.

Secondly, **Chemicals & Finishing** have a direct impact both on functionality and aesthetic characteristic and affect to a large part to what extent a product is more or less sustainable. Creative use of alternative finishes that require less potentially harmful substances can be one way to make a product more sustainable. On the other hand, aiming for a design that embraces signs of aging can make the use of coating and other finishes overall redundant.

Thirdly, clever design and appropriate choice of material and finishing can af-fect the amount and variety of **Materials** used, affect other aspects such as ease of repair and recyclability and thus make a product more or less sustaina-ble.

From a technical point of view, this focus on the entire **Product Lifespan** is an important part in designing more sustainable products. For instance, extending the product life can directly reduce its environmental impact.

This related both to **Reparability** by considering scenarios in which certain parts of the product need to be replaced or refurbished and Longevity by improving overall quality and emotional durability.

Both aspects can be supported by a suitable **Product Ecosystem**. Additional product can for instance increase product lives by fostering caring behavior and facilitating maintenance procedures.

Brown Boxes – Organisational Aspects

Although they as well include technical topics such as traceability, they primarily refer to questions or issues that affect the organisation of producing, transporting and disposing or recycling of the products.

With regards to leather products and the related global supply chains, **Sourcing** is a critical sustainability issue. Carefully considering geographic origin, socio-economic circumstances and other aspects can help rendering a product more sustainable. From a sustainable business model point of view, establishing trustful and sustained collaborations can be both economically attractive and in favor of sustainable development.

This relates directly to the **Traceability** of hides as well as chemicals through the supply chains. Especially regarding leather products, tracking chemicals and how they are handled is an important step in designing more sustainable products. This does not only relate to legal compliance but might offer additional economic benefits by providing strong foundations for green claims and even offer additional information at the point-of-sale that could increase overall sales.

From a systems perspective aiming for more sustainable products requires to consider both pre- and post-consumer phases of a product. In this context **Process Optimisation & Waste Avoidance** refers to specific design decisions that aim at reducing for instance energy and raw material consumption. In the case of leather products optimizing cutting layouts to make the most use of a single hide is one way of avoiding waste. Using thinner and lighter types of leather (e.g. sheep leather) for a specific product instead of splitting at thick piece of cow leather is a more efficient use a material.

The same holds true for the post-consumer phases. There are several ways to reuse and recycle leather products and parts of them. Therefore, considering **Recycling & Circular Economy** in the early design phases offers both business and sustainability opportunities.

Purple Boxes – Economical and Consumer Topics

The purple boxes refer to economical and consumer topics including business models and the role, awareness and behaviour of consumers.

Usually leather products are just one part of a **Business Model**. Considering and ideating new business opportunities around a product can make it more sustainable. This relates in particular to the notion of circularity. Product-Service-Systems are one example of potential solutions.

Marketing & Communications can have a strong influence on the way consumers interact with a product and whether or not they are willing to pay a par-ticular price for it. This box is directly related to topics such as traceability of chemicals or longevity. Communicating for instance proper chemical management can support a more sustainable business model by providing robust data on convincing green claims.

In order to be effective in both communicating to potential consumers and designing products and services for specific user groups it is highly important to know: **Who is your Consumer?** There is a large body of methods and knowledge on understanding target groups. With regards to sustainable development and product design, approaches such as design for product attachment or longevity require precise information on specific user groups to be effective. While some designs might lead to higher degrees of emotional attachment for one group this does not have to be the case for another one.

Based on this knowledge about consumers and target groups, aiming for more sustainable leather product can also refer to **Consumer Behaviour Change**. Clever design and convincing product ecosystems can influence consumers for instance to move from fast fashion to long-term caring practices. Design con-cepts need to be based on a systemic understanding of the product use cases and which types of user behaviour is more sustainable.

Orange Box – Legal Aspects and Business Potentials

The overarching legal and institutional framework that applies to the product at hand is represented by the orange box. It is closely linked to other aspects such as business models that are based on current regulatory developments. With regards to leather product this refers in particular to chemical management and is directly linked to aspects such as traceability and sourcing.

Impulse Questions

For a full-page version of the leather product design canvas see p. 4-5.

or download A3-PDF here: https://opus4.kobv.de/opus4-h-da/files/253/Rehn_2021_Leather_Product_Design_Canvas.pdf

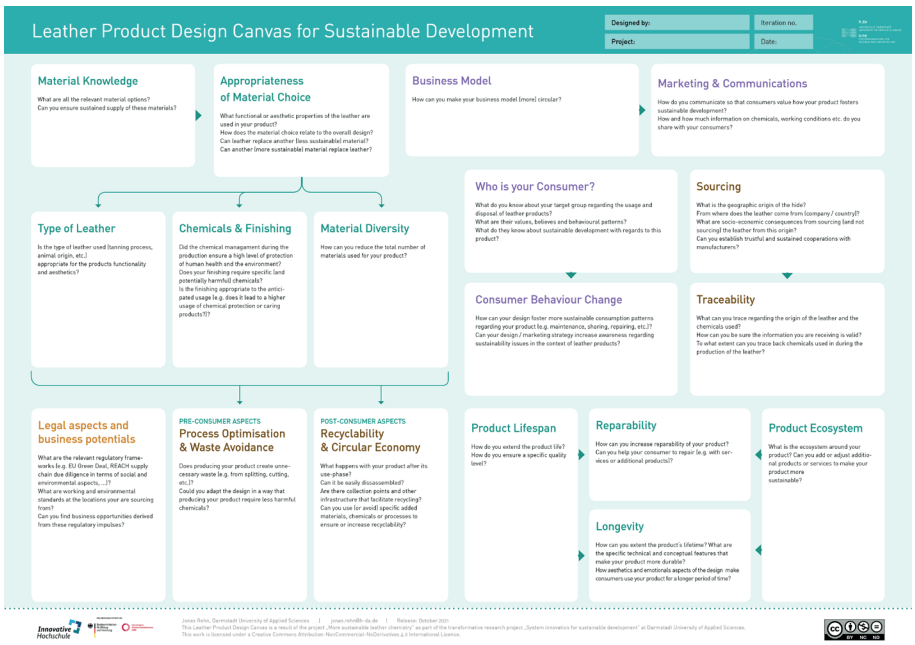

Fig. 5.2.2) Leather Product Design Canvas, DinA3 (Rehn, 2021) (full size illustration on p. 4-5)

In each of the 18 boxes, impulse questions specify the scope of these categories (Fig. 5.2.2). These questions are meant to guide the design process and initiate considerations to improve the design concept. As each project, product

and supply chain is different, the size of boxes or number of impulse questions do not reflect the importance or relevance of a specific topic.

Additional arrows and lines indicate clusters, interdependencies and direct relations. However, as leather supply chains are complex systems, all boxes are related to each other to some extent. Therefore, these indications should be seen as rather most basic or obvious relations and clusters.

Application of the Leather Product Design Canvas

Users of the Canvas

The complexity inherent to the field of sustainable development requires an inter-disciplinary systems thinking approach. With regards to leather products, designers might be faced with contradicting targets that make it even more difficult to define a proper briefing for more sustainable products. The fashion industry, for instance, is demanding for continuously new styles and approaches that often follow a business model of planned obsolescence. Instead, more sustainable and innovative leather products (and related services for that matter) could include business models or strategies that have a profound impact on many other departments of a company than product development such as sourcing, quality management, business development, marketing etc. Understanding the paramount role design might play to create more sustainable products and influence more sustainable consumer behaviours requires a paradigm shift that puts design decisions at the core of strategic management. Therefore, design cannot be done by one person alone but rather needs to be a team effort across disciplines.

This being said, ideally, the canvas shall be used by an interdisciplinary team comprising as many roles as possible that relate to the design and development of new leather products (such as sourcing, marketing, etc.). As this mode of work poses additional challenges and threats for a design process, it is recommended to use well-prepared workshops when applying this canvas in interdisciplinary teams. In this way, the designer's role might be extended from simply designing products to actually facilitating and moderating the design process, taking all relevant impulses and requirements from other disciplines into account. At the same time, to get the most out of this canvas to thoroughly design leather product while considering as many relevant sustainability issues as possible might require a change of corporate culture or mind-set in some organisation, fostering open-minded and transparent communication across departments and disciplines.

Mode of Work

As mentioned before, the canvas is not meant to be a strict formula or checklist but rather an exploratory analysis and conceptualisation tool that can be used and revisited (iterative process) at any stage throughout the design process.

Boxes and questions do not necessarily have to be addressed in their order of appearance.

While not all impulse questions might apply to each project, they could raise awareness or identify gaps of knowledge that need to be addressed before moving on in the design process. Therefore, the canvas is both explorative inspiration as well as a simplified evaluation tool.

The canvas can be fulfilled by one person alone or as part of a workshop or team effort. It is recommended to use the canvas in an iterative manner. Additional information boxes in the header of the canvas support this iterative mode of work. As illustrated in fig. 5.2.3, it might be useful to note down ideas and concepts directly on the canvas. This also encourages short and pointed descriptions due to limited space available. At the same time, the canvas can be used and adjusted to the needs of each individual project. Therefore, team work-shops might require more space or additional worksheets to go deeper into specific boxes or topics.

Especially with regards to workshops, it can be useful to combine the canvas with other tools and techniques from the field of design thinking [20]. Workshops applying this canvas should be planned and orchestrated according to the usual principle of design- and brainstorming workshops, curating an open mind-set and appreciating new, disruptive and sometimes unrealistic ideas to go beyond current concepts and solutions. After each workshop, the canvas worksheets should be analysed in detail by the workshop facilitator to extract insights and concepts that otherwise might be lost.

One of the most important aspects of working with the canvas is to identify and indicate relations and interdependencies. Therefore, it is recommended to use arrows, lines and other graphical or written information to illustrate connections and foster systems thinking (see e.g. fig. 5.2.3).

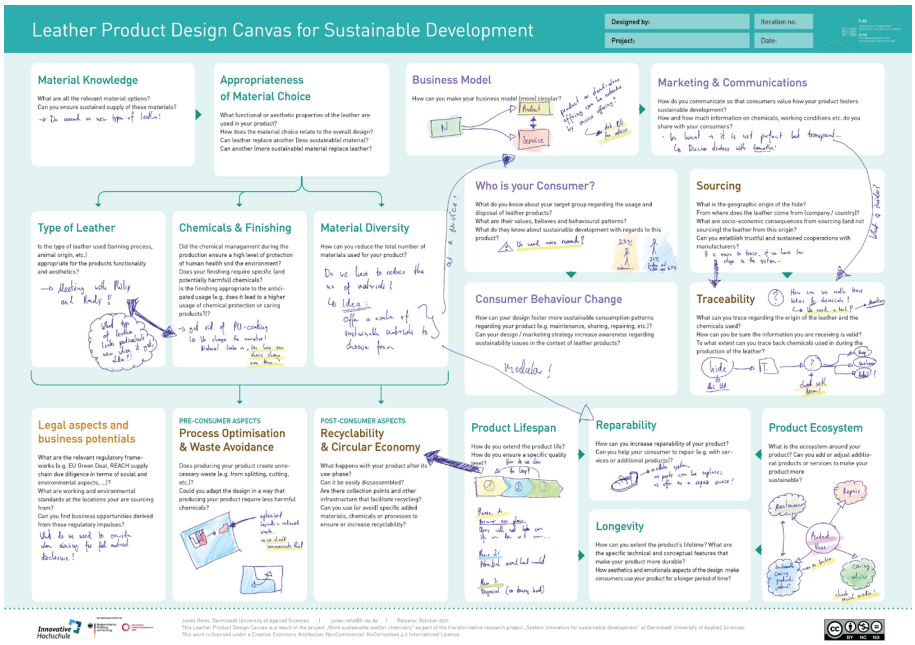

Figure 5.2.3: Applied Leather Product Design Canvas for female dress shoe

It is recommended to use the Leather Product Design Canvas while applying the aforementioned Handbook of Leather Design for Sustainable Development. While the handbook aims at deepening one's knowledge and broadening one's scope with regards to more sustainable leather products, they shall be seen as both piece of reference and exploratory source of inspiration like comparable guidelines in the field of circular economy [21] or even public design [22].

Open-End Template

Although this canvas has been co-developed and tested with industry partners and an interdisciplinary group of scientific experts, there might be projects or phases for which important aspects or new trends are entirely missing. Users of the canvas should therefore feel free to adjust and extent the canvas accord-ing to the needs of the project. We encourage users who have feedback and ideas for improvement to get in touch with us.

Discussion

The Leather Product Design Canvas shall be a rough explorative tool that broadens a design team's scope and highlights blind spots. It is not meant to replace comprehensive research and analysis. Although this tool has been developed together with stakeholders along the leather supply chains including industry and NGOs, its usability and effectiveness still needs to be evaluated. It is assumed that the visual simplification of the system's complexity by colour-coded boxes and impulse questions enables design-teams to easily take a system-oriented perspective. By doing so, design teams are more likely to address relevant issues and consider interdependences that otherwise might be overlooked. This being said, proof of concept is still needed.

Therefore, more research is needed to understand the potentials and weaknesses of such tools in the design process with regards to sustainable development.

Although this tool has been designed specifically for the context of leather products, it can be assumed that key aspects as well as the overall approach can be applied to other product categories and design project respectively.

As this Leather Product Design Canvas is a simplified spin-off of more comprehensive design handbook related to the same subject that are currently being prepared for publication, it is recommended to refer to the handbook if specific questions arise while applying the Leather Product Design Canvas.

More research is needed to understand implications and limitations of a canvas like this to foster the development of more sustainable leather products. More precisely, questions regarding the role of canvases during the design process as well as the specific themes and impulse questions in the herewith proposed

canvas need to be answered. With regards to transdisciplinary approaches, it is recommended to investigate these research questions in close collaboration between industry, academia and users.

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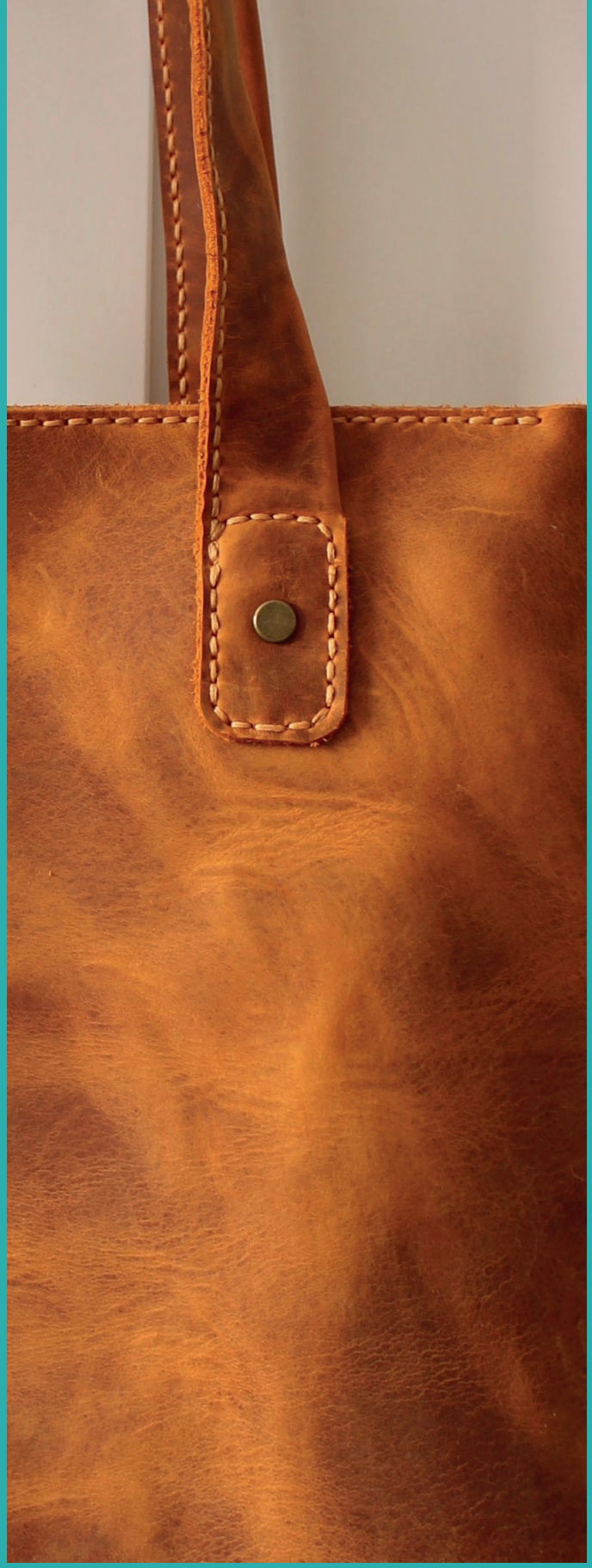
6

Back Matter



Field Test of this Handbook

Jonas Rehn-Groenendijk

This handbook is the result of a transdisciplinary collaboration of representatives from academia, industry and NGOs and other experts. Therefore, the concepts and ideas presented here are both derived from theory and science as well as practise and experience. To what extent this handbook actually contributes to more sustainable leather products can only be assessed in the future once the information given on these pages has been applied to real world design challenges. However, in order to evaluate to some extent the usability and effectiveness of the **Leather Product Design Canvas** (Chapter 5.2) and this **Handbook** an international Leather Design Competition & Mentoring Program has been conducted from March 2022 until September 2022. The overall competition consisted of two phases.

Fig. 6.1.1) Call for Participation of the Competition (6 page PDF)

Phase 1 – Entry Level

Everybody interested or involved in designing and developing leather products was allowed to join the competition. This included - but was not limited to - professional and early career designers, design agencies, students of design and related disciplines, leather brands and start-ups. The participant(s) or

the participating teams took full responsibility for submitting only original creations. They were asked to create a design concept for a leather product based on the „Leather Product Design Canvas for Sustainable Development" by using the poster template provided.

Submissions were then evaluated by a transdisciplinary jury of experts from industry and science based on the following criteria:

- **Consideration of Leather Product Design Canvas**
- **Systemic perspective on sustainable development**
- **Overall aesthetic and conceptual quality of design**
- **Degree of innovation**
- **Market opportunities**
- **Feasibility**

Phase 2 – Mentoring Level

14 participants (mainly from Indonesia, Bangladesh and India) including 3 teams of multiple participants reached phase 2 of the competition and were selected for the mentoring program and were given the chance to participate in an in-depth teaching phase led by a transdisciplinary team of 11 experts from industry and academia. The aim of this process was to enable the participants to gain (more) knowledge and skills in leather as a material and related topics such as sustainable development, taught by leading experts in this field. The mentoring program was held in three online sessions comprising a mix of input speeches, project clinics and personal consultations focusing on the final design task. Topics and content of the mentoring program was based on this handbook and was relevant both to early career and professional leather product designers.

Final Task

After the mentoring sessions all finalists were asked to elaborate their design concept for a leather product based on the "Design Guidelines for More Sustainable Products" and the information provided during the sessions. They were given 6 weeks to complete this task.

This final deliverable was expected to comprise 5-8 A4-pages combining text and illustrations addressing the following questions:

1. Overall concept

What is it about?
Was is the specify type of leather, tanning agent, etc
How does it relate to sustainable development?
What is the target group?

2. Context

How does it relate to Sustainable Development in the context of leather?
Which problems does it solve?

3. System

How does it relate to the leather supply chain?
What is its business ecosystem? What is the business model?

4. Additional illustrations

(e.g. photos, sketches, CAD renderings, models, etc.)

5. A Leather Product Design Canvas referring to the design concept

The submitted concepts were then evaluated by the experts from academia and practise using a voting sheet comprising these 12 items:

Categorie	Guiding Questions
Consideration or material provided	The submission considers topics illustrated in the leather product design canvas.
	The submission shows comprehensive understanding of the information given in the „Leather Design Guidelines“.
Systemic perspective on sustainable development	The focus of the submitted concept exceets the mere product.
	The product considers the entire (or at least parts of the) supply chain of the concept.
	The concept directly addresses challenges related to sustainable development.
	The submission demonstrates a contemporary understanding of the current state of research regarding sustainable development.
Aesthetic and conceptual quality	The design conveys a coherent, convincing and clever idea.
	The aesthetic design is attractive and appropriate regarding the target group.
Innovation	The concept is new or applies existing elements in an new or innovative way.
Market opportunities	How would your design perform on a (global or regional) market.
	The concept is scalable.
Feasibility	It is possible to produce the product using a reasonable amount of money, resources and time.

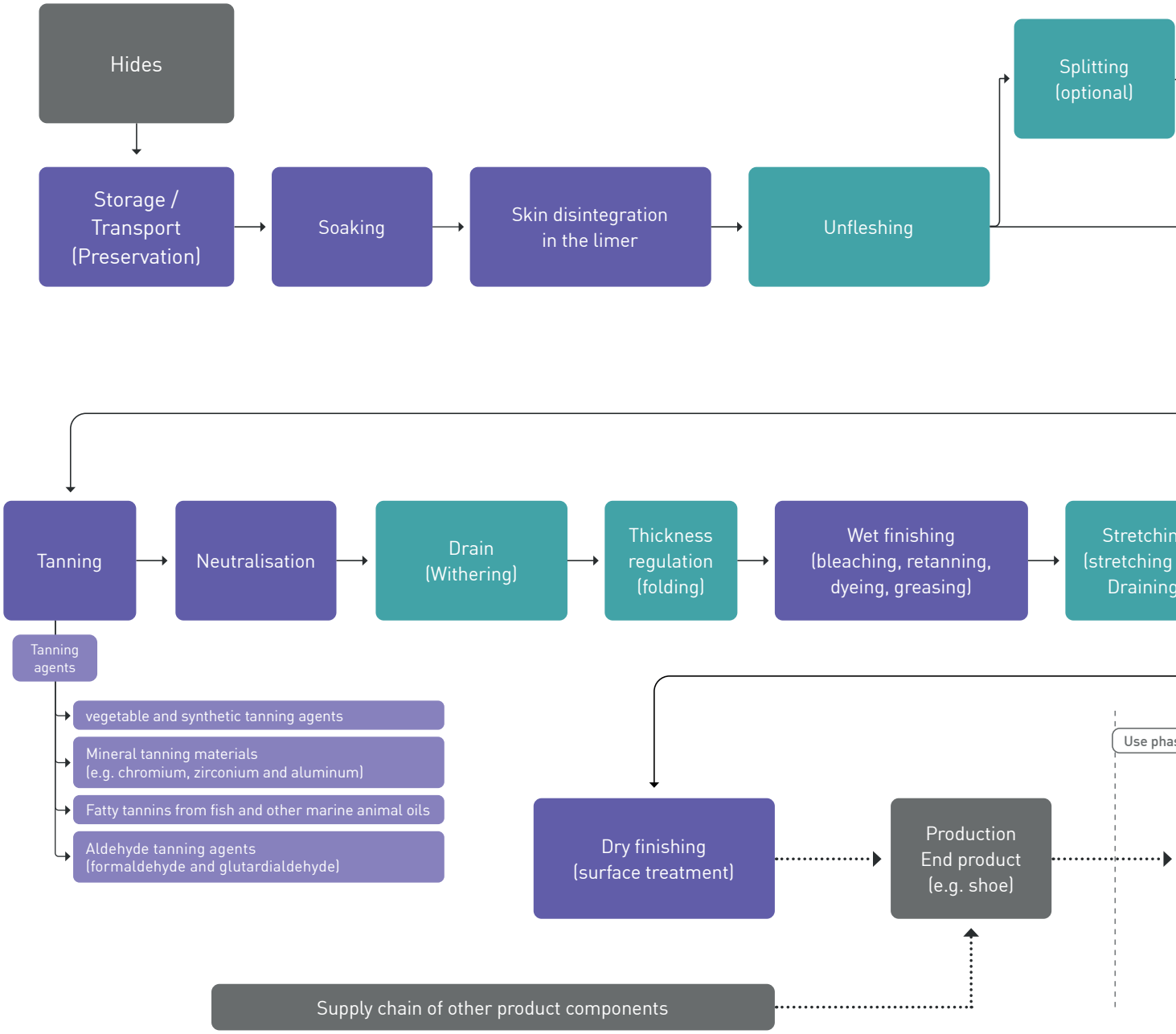
Results & Discussion

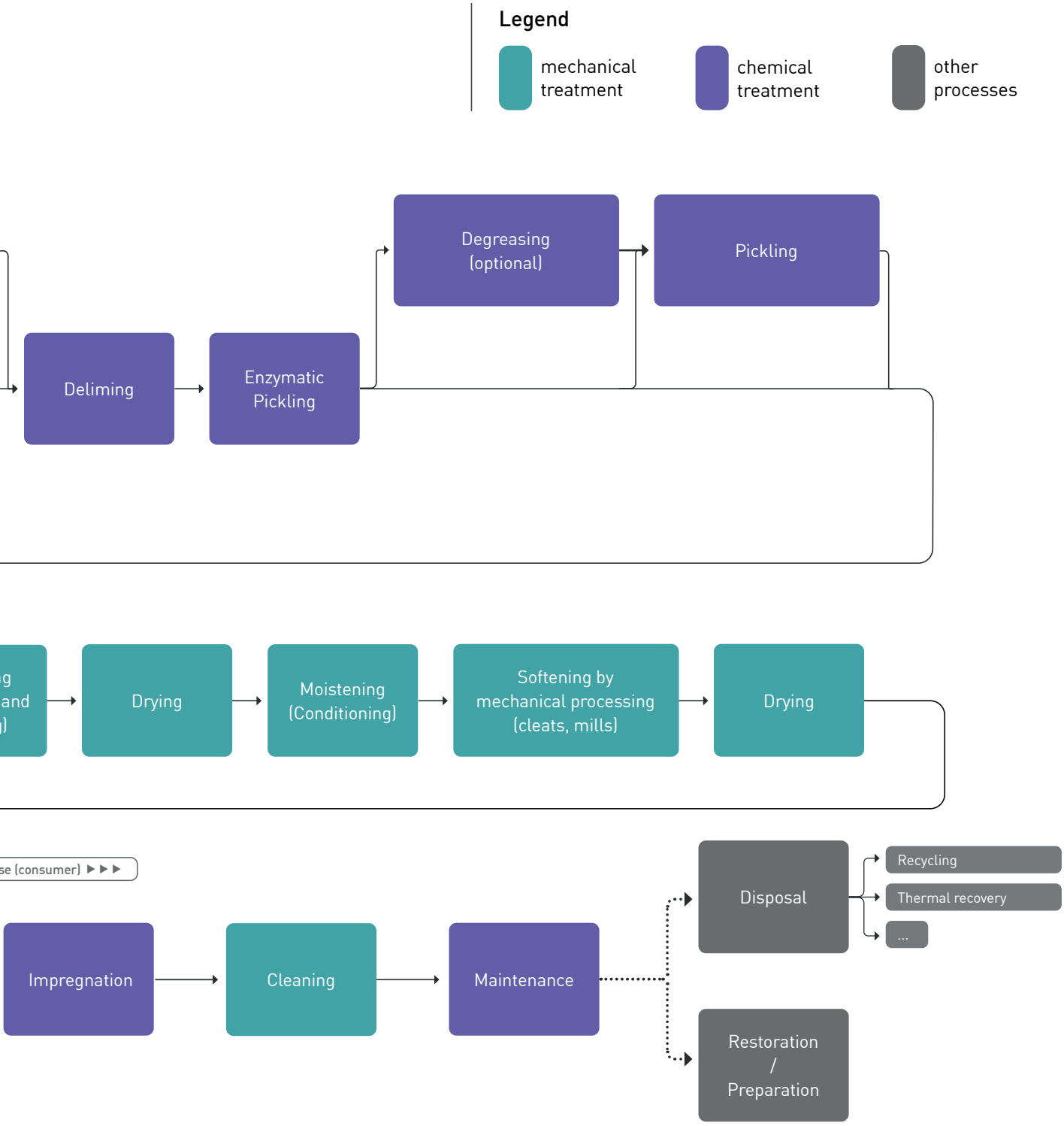
Most of the participants showed in their final submissions a significant increase of complexity and depth regarding sustainable development and systemic understanding of leather and leather supply chains. All in all, both the **Leather Product Design Canvas** and the **Handbook of Leather Design for Sustainable Development** served as tools to broaden the participants scope and increased the depth of each individual concept. Participants confirmed an added value of the diversity of topics and aspects that are addressed in the documents.

At the same time, applying the handbook could be seen as an iterative process itself, in which users revisit particular chapters or themes over and over again, deepening their knowledge and skills in practically applying the information provided. This is confirmed by statements of some participants who emphasize the long-term use of the material beyond this specific task and competition.

Nevertheless, as stated in the first chapter of this handbook, this document is meant to be an open and living one, which will need to be adapted and improved in line with lessons learnt during its application.

Simplified illustration of tanning process




Legend
mechanical treatment
chemical treatment
other processes
Degreasing (optional)
Pickling
Deliming
Enzymatic Pickling
Drying
Moistening (Conditioning)
Softening by mechanical processing (cleats, mills)
Drying
Impregnation
Cleaning
Maintenance
Disposal
Recycling
Thermal recovery
...
Restoration / Preparation

Further Readings and more

Websites

- Scenario Story - Leather 2035 (Darmstadt University of Applied Sciences)
  sne.h-da.de/fileadmin/Einrichtungen/sne/sne_2019_-_Szenario_-_2035_B.pdf
- Project Website: More Sustainable Leather Chemistry:
  https://sne.h-da.de/leather-chemistry
- Reach Radar
  An early warning system for chemicals management
  www.oeko.de/reach-radar
- Interlinks of Green Deal Policies - Interactive Map
  Research Group sofia 2022
  https://www.sofia-research.com/about-us/european-green-deal-analysis
- Marketplace for alternatives to chemicals of concern
  https://marketplace.chemsec.org/Alternatives
- Tool to identify future chemicals of concern
  https://sinlist.chemsec.org/
- The Higg-Index
  https://apparelcoalition.org/the-higg-index
- Leather Working Group (LWG)
  https://www.leatherworkinggroup.com
- IVN Leather Label
  https://naturtextil.de/qualitaetszeichen/naturleder/
- Label „Cradle to Cradle Certified"
  https://www.c2ccertified.org/
- Blog „What is Genuine Leather?"
  https://audeamuswatch.com/blogs/news/what-is-genuine-leather
- UNIDO Leather Panel
  https://leatherpanel.org/

- ISO14001 - Environmental Management
  https://www.iso.org/iso-14001-environmental-management.html
- Liberty Leather Goods
  online reference resource about leather working and leather craft
  https://www.libertyleathergoods.com/
- At the Forefront of Sustainable Fashion, Peterson Stoop Reconstructs Tattered Sneakers into New Patchwork Designs
  https://www.thisiscolossal.com/2021/12/peterson-stoop/
- Leather Naturally - Global Resource to learn about leather:
  https://www.leathernaturally.org/Education/Fact-Sheets

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Umweltbundesamt - UBA: **The Guide on Sustainable Chemicals.** The Guide on Sustainable Chemicals helps manufacturers, formulators and end users of substances to select the more sustainable solution. https://www.umweltbundesamt.de/en/publikationen/guide-on-sustainable-chemicals

Talks & Podcasts

- **Sneakerjagers PURE - De Sustainable Podcast**
  S01 E01 | Willa Stoutenbeek & Christiaan Maats
  https://youtu.be/7shcDX2VOBc

Authors

Karl Borgschulze draws on over 30 years of experience and an extensive network in Asia, Europe and the World to design sustainable sourcing solutions for global manufacturing industries. As managing director of Consulting Service International, he works directly with stakeholders in important procurement market. Karl Borgschulze has comprehensive expertise in the optimisation of value chains and international sustainability management. Due to his well-founded industry knowledge and global commitment, Karl has an extensive network of international NGOs, companies, government institutions and media circles. In recent years, he has increasingly focused on the development of industry solutions by bringing together diverse industry players in the Partnership for Compliance and other initiatives.
Contact: info@applied-csr.com

Prof. Dr. Dirk Bunke is a senior environmental scientist working at the Öko-Insitut e.V. in Freiburg, Germany. His main research areas are toxicology and risk assessment of chemicals, chemicals policy, REACH and sustainable chemistry, substitution; hazardous substances in consumer products. Bunke is author of the „Guidance on sustainable chemicals" and the screening tool „REACH Radar". Both instruments support especially small and medium sized enterprises to check whether they use problematic substances – and to find appropriate substitutes. He represents the European Environmental Bureau (EEB) in the Expert Group of the European Chemicals Agency (ECHA) on persistent, bioaccumulative and toxic chemicals (PBTs). He is a teacher at the University of Education of Freiburg and at the University of Freiburg.
Contact: d.bunke@oeko.de

Andrés Castro, associate researcher in Circular Economy and Life Cycle Assessment at the Darmstadt University of Applied Sciences. He holds a degree in environmental engineering and a master in environmental and resource management. His experience is based on formulation, implementation and evaluation of sustainability strategies for companies with a focus on circular economy. Likewise, developing indicator systems to measure and report sustainability data. His research area includes how to foster the transition to a circular economy free of toxic materials and safe-by-design product development processes.

Simone Charlet develops strategic solutions with focus on sustainability, compliance, supply chain management and innovation for clients in the fashion and footwear industry as consultant at Consulting Service International. She has experience managing circularity related projects in Asian supplier markets, developing new sustainable materials for the fashion industry and supporting the design of strategic industry solutions by working directly with stakeholders from research, government, consumer markets and manufacturers.

Nina Conrad (bttr GmbH) studied political sciences and Islamic studies at the Universities of Zurich and Barcelona. She has been working as a sustainability consultant in the textile and leather industry for several years, specializing in traceable supply chains. Her core business is the production of leather and leather goods that originate from animals from certified organic farms. She works closely with farmers and regional slaughterhouses in Germany and Switzerland. Her aim is to make the leather industry more sustainable and transparent, while at the same time raising consumer awareness of the responsible manufacture of leather products. Her projects are summarized on the platform Traceable Leather. Besides she is a founding partner of the Sustainable Leather Foundation, and a co-founder of the Fibershed affiliate DACH.
Contact: nina@bttr.gmbh

Ing. Egbert Dikkers MBA, was the Global Director ESG for Royal Smit & Zoon. His prime responsibility was to lead the company's ambitious ESG program, in order to reach the mission to create a socially and environmentally sustainable leather value chain, together. Egbert Dikkers has been working in the chemical industry, and specifically the leather industry for 30 years. Next to his role within Royal Smit & Zoon, he was one of the founders of the Leather Working Group Tannery of the Future self-assessment and was Co-Chair of this sub-group within the Leather Working Group. Next to this, he was chairing the leather industry association Leather Naturally, that is focusing on education and promotion of leather.
Contact: egbert.dikkers@gmail.com

Dr. Jiska Gojowczyk holds a doctorate awarded by the Faculty of Management, Economics and Social Sciences of the University of Cologne. As a SÜDWIND researcher, she works on responsibility in value chains, especially on the problems in the production of shoes and leather and on their procurement with social standards. She is member of the advisory board of the Sustainable Leather Foundation. Previously, she spent many years at the Max Planck Institute for the Study of Societies in Cologne investigating how actors in different contexts interpret globally defined goals to guide their actions. During this time, she was also a guest at the Copenhagen Business School and the Asian Center of the University of the Philippines.

Burcu Gözet is a researcher at the Wuppertal Institute for Climate, Environment and Energy. Affiliated to the Division Circular Economy, her research scopes environmental pressures related to global value chains and therewith, potential transformative solutions. Burcu Goezet is active in various national and international projects, while her special focus is on the textile industry. Within the project "Consultancy and Support for the German Partnership for Sustainable Textiles ("Textilbündnis") on its Circular Economy Project", for instance, she assessed waste prevention strategies and determined circularity measures along the textile value chain. Currently, she is working on the conceptualization of a circular textile economy against upcoming policy strategies (as e.g. foreseen within the EU Textile Strategy).
Contact: burcu.goezet@wupperinst.org

Heike Hackmann has been working on the topic of sustainability in the leather industry since the 1990s. Her main focus is on communicating facts and contexts to employees in the trade and to consumers. Among others, she has a long working relationship been with a supplier of ecological leather (Ecopell GmbH) in Southern Germany. In recent years, her work focus has changed towards education for sustainable development (ESD). At the beginning of April 2022, she took over the management of the State Agency for Education for Sustainable Development Schleswig-Holstein (BNE-Agentur SH).

Ann-Cathrin Jöst is a Research Associate at the University Darmstadt of Applied Sciences. She holds a Bachelor Degree in Business Administration and Master Degree in Sustainability Sciences and Policy. Her research interest lies in complex system-thinking, a discipline that aims at understanding the dynamics between socio-economic-ecological problems and their solutions. Because systems can differ between the individual, group and society as whole, she enjoys looking at them and working with them through an interdisciplinary and transdisciplinary perspective. Besides, Ann-Cathrin is very interested in putting theory into practices. She has a passion for participatory research designs, which encourage her to translate practical experiences into new theories. Currently she is working in different university projects, where she is working on the development of more sustainable business models .
Contact: ann-cathrin.joest@h-da.de

Eleni Kaluziak is researcher at the Department of Social Sciences, Darmstadt University of Applied Sciences. In earlier career steps, she gained profound experiences in risk management and project management. Eleni holds a degree in business administration and economics. In the transdisciplinary research-based transfer project "More Sustainable Chemistry in Leather Supply Chains" she is co-leader of subproject 2 on "IT tools and governance for traceability" of chemicals along the leather supply chains.
Conctact: eleni.kaluziak@h-da.de

Karen Lehmann has been a research officer at the Schader Foundation since July 2018. She holds a degree in European Studies from Maastricht University and a master's in political science from the Friedrich-Alexander University Erlangen-Nuremberg. At the Schader Foundation, she is involved in the project „System Innovation for Sustainable Development (s:ne)", where she focuses on providing opportunities for meaningful exchange in support of the transdisciplinary work process in the different subprojects.

Andreas Meyer has been the managing director of the VDL (Verband der Deutschen Lederindustrie e.V. / German Leather Federation) since 2018. He first learned to be a farmer and then studied agricultural sciences. As a graduate agricultural engineer he began his career in the by-products department of a large slaughterhouse, then moved to a company producing animal fats, after which he worked for many years in the skin trade.

Dr. Gerhard Nickolaus holds a Doctor in Chemistry from Germany and has more than 40 years' experience in production facilities across Asia. His expertise covers chemical management, identification of hazards and implementation of solutions at management and factory level. He also possesses the highest expertise on physical and chemical testing procedures. Former director of PFI Hong Kong Ltd. and PFI Fareast Ltd., he founded the International Shoe Competence Center in Pirmasens (ISC) and in Asia and has established testing, training and education centres in Asia. With four decades of experience in analytical testing and quality inspections of footwear, he has exceptional expertise in footwear, leather and synthetic technology and workmanship.

Pradeepan Ravi works as Project Coordinator at Cividep India. He manages Cividep's work concerning the leather and footwear sectors in India, which includes conducting research on working conditions, lobby and advocacy with companies and government agencies. His work at Cividep includes building a multi-stakeholder partnership focused on improving social and environments conditions in the leather sector. In the process he has gained first-hand experience of organizing home-based workers, mapping sub-contracting supply chains of global footwear brands and conducting research on working conditions. Pradeepan has over 8 years of experience working on issues such as labour, housing for poor, environment, and waste management. He is passionate about working for issues concerning workers rights and business and human rights.

Contact: pradeepan@cividep.org

Dr. Jonas Rehn-Groenendijk is senior design researcher at the Darmstadt University of Applied Sciences and holds a doctorate in design research and industrial design. His research interests include system innovations, design for behaviour change and design for sustainable development. His methodological focus is on co-creational approaches, empirical design research and evidence-based design. Jonas is active in the transdisciplinary research-based transfer project "More Sustainable Chemistry in Leather Supply Chains" and is leading the subproject on "Handbook of Leather Design for Sustainable Development", in which he uses design methodology to support co-creative processes among industry, academia and the public. He is reviewer and teaches on design methodology in Germany and the UK.
Contact: jonas.rehn@h-da.de

Patrick Rojahn (M.Eng.) works in the field of chemical reaction engineering at Darmstadt University of Applied Sciences since 2016. His research interests include the investigation and application of microreaction devices and flow chemistry for more sustainable and bio-renewable chemical transformations. Since 2018, he is active in the transdisciplinary research-based transfer project „More Sustainable Chemistry in Leather Supply Chains" and in particular in the sub-project „Chemical and process innovations". This project aims to improve the sustainability of the production and use of chemicals along the leather supply chain, which is addressed by developing an easy-to-use life cycle assessment tool and syntheses of selected chemicals with microreactors.
Contact: patrick.rojahn@h-da.de

Prof. Dr. Frank Schael teaches chemical engineering at Hochschule Darmstadt. He received his doctoral degree in Physical Chemistry. Frank Schael worked as a scholar and postdoctoral research associate with the Technion in Israel, as a group leader with the Universities of Erlangen and Potsdam, before he joined Ehrfeld Mikrotechnik, a company for micro process engineering. There he was heading the chemical process development and occupied the key account management for Nothern America and India. He was appointed as professor in 2014.
Contact: frank.schael@h-da.de

Dr. jur. Julian Schenten is a senior researcher at Darmstadt University of Applied Sciences and project manager of the research-based transfer project "More Sustainable Chemistry in Leather Supply Chains". The publicly funded project deals with the challenges of a more sustainable chemistry in the global leather supply chains and involves international stakeholders along the supply chains as well as NGOs and academia from various disciplines to work together on innovations.
Contact: julian.schenten@h-da.de

photo by Jürgen Mai

Inge Specht-den Boer Museum coordinator and senior curator at Schoenenkwartier, Waalwijk, the Netherlands. She was trained as a textile conservator at the State Training School for conservators. Her career as a curator started more than 25 years ago and over time she has developed into a nationally and internationally respected expert on leather and footwear. In the last five years she has played a substantial role in the development of the Schoenenkwartier, the totally revised version of the former shoe museum in Waalwijk. Her research interests include the history of leather and shoe manufacturing in the Dutch region The Langstraat, the social historical role of footwear in the determination of the wearer's identity and the sustainable use of leather and footwear in a historical context versus sustainability as a concept in the 20th and 21st century.

photo by Peter Uijtdehage, 2021

Dr. Charis Stoica (maiden name: Eisen) is researcher in the project "System Innovation for Sustainable Development" at Darmstadt University of Applied Sciences. Originally from Germany, Charis Stoica received her Ph.D. in Psychology from Kobe University in Japan. Her research focuses on interactions between individuals and their environments. She published on the role of social status and culture in individual decisions and on individual behavior related to sustainable development. Currently, she uses a transdisciplinary research approach and applies psychological theories to urgent real-world problems. Together with her colleagues, she established a citizens' panel in Darmstadt, Germany and conducts regular surveys to inform the development of sustainable innovations.
Contact: chariseisen@gmail.com

Deborah Taylor, PCQI Deborah is the Managing Director of the Sustainable Leather Foundation, a not-for-profit Foundation, set up specifically to support the leather industry in becoming more sustainable. The purpose of the Foundation is to provide a global platform for the benefit of all stakeholders in the leather value chain. A practitioner member of the Chartered Quality Institute and a certified SA8000 lead auditor, Deborah also currently works as a Consultant for the UNECE on the project to "enhance traceability and transparency for more sustainable value chains in the garment and footwear sector". In addition, she is a Council Member for the Society of Leather Technologists and Chemists.

Dipl.-Ing. Ekkehard Werner, Sustainability Manager HELLER-LEDER GmbH & Co. KG for the areas of environmental protection and occupational safety, compliance, energy management as well as product and system certification. His field of work includes the development and application of technical and organisational management solutions for the implementation of various customer and certification requirements, taking into account the company's strategic sustainability policy. With his expertise, he supports the cooperation between industry, authorities and research in various expert committees. He is involved in projects on the systematic determination of data on climate and environmentally relevant aspects in leather production. One focus is, among others, communication in the supply chain, transparency and traceability, in procurement and evaluation of chemical products. Ekkehard Werner is head of the Environmental Management and Laboratory Department. He is a regular guest speaker on environmental topics in leather production.
Contact: e.werner@heller-leder.com

Eva Wolf works at the Society for Institutional Analysis (sofia) at the University of Applied Sciences Darmstadt. During her master's degree „Risk Assessment and Sustainability Management" (RASUM), she dealt with sustainability-related challenges of an textile importer in an interdisciplinary project. Based on this, she developed strategies for a more sustainable chemicals management in the textile supply chain in her master thesis. As a student assistant, she already supported sofia in the supply chain action of the EU project „LIFE AskREACH". Since November 2021, she has also been working as a research assistant at sofia on this topic and on the linkages to a resource-efficient „circular economy" and a „non-toxic environment" in the context of the EU's „Sustainable Product Initiative".
Contact: eva.wolf@h-da.de

Further Contributors

This handbook is the result of a comprehensive iterative process comprising several workshops, discussions and asynchronous tasks. Therefore, apart from the above mentioned authors, we want to express our appreciation for participating in this transdisciplinary process during interviews, workshops and asynchronous work and sharing valuable insights and input:

- Prof. Timo Braun, Darmstadt University of Applied Sciences
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- Sabrina Zinner, PUMA
- and many more

Organisations

h_da

Darmstadt University of Applied Science (h_da) is one of the largest and most distinguished universities of applied sciences in Germany. Its excellent reputation is the result of a scientifically grounded, real-world approach to higher education and innovative transfer projects from research to industry. As part of its transfer strategy, based on the objectives of sustainable development, h_da has implemented the project on More Sustainable Chemistry in Leather Supply Chains.

h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
itp
INNOVATIONS- UND
TRANSFORMATIONSPLATTFORM
FÜR NACHHALTIGE ENTWICKLUNG

Innovation and Transformation Platform for Sustainable Development (itp)
Together with actors from companies and associations, politics and administration as well as science and civil society, the Darmstadt University of Applied Sciences (h_da) wants to actively promote change processes towards sustainable development. To this end, the h_da has established the "Innovation and Transformation Platform" for sustainable development (itp). On the itp, h_da researchers support the above-mentioned actors with their content-related and methodological expertise to develop novel solutions in specific fields of action for which societal needs are apparent, ie. 'changing production and consumption patterns' and 'infrastructures on the ground: system mobility and energy networks'. Get in touch with the itp at https://itp.h-da.de/.

bttr GmbH has set itself the goal of promoting the local production of natural materials. With the project Traceable Leather, they build up and manage local value chains for leather and leather products. They only use the hides of cattle, sheep, goat and deer that have been treated with respect and have spent their lives on a regenerative, organic or other sustainable farm. They sell raw hides, leather or finished leather goods to designers, artisans and companies and support them in making their leather value chains more transparent and sustainable.

Website: traceableleather.com

Cividep India has been working on corporate accountability and workers' rights since the year 2000. Cividep's work aims to safeguard the rights of communities, especially workers employed in global supply chains such as garments, leather, and electronics. We strive to hold corporate entities accountable for the impacts of their business on workers and the environment. To this end, Cividep conducts research on working conditions and corporate conduct across a range of export-oriented industries, engages in worker education, and advocates for policy change. Cividep has been active in the leather sector since 2013. It is currently working in a European-Asian consortium called ‚Together for Decent Leather', financially supported by the European Union, looking at improving the living and working conditions of workers in the leather value chain."

Website: www.cividep.org

CSI is an international advisory firm with long-standing experience and extensive network in Asia, Europe and the world. Headquartered in Hong Kong and represented on three continents, CSI has practical and direct experience in Asian sourcing markets. Its experienced team develops practical industry solutions. As initiator of the Partnership for Compliance, CSI works together with diverse partners to develop future-ready solutions with a focus on sustainability, innovation and communication.

Website: www.applied-csr.com

The company **HELLER-LEDER GmbH & Co. KG** is a leading manufacturer of high-quality upholstery leather for the automotive and furniture industries. Sustainability has been the visible success of the company for over 100 years - it is one of the few companies to follow the tradition of the full tanner, i.e. the production of leather starting from the raw material, the animal hide, to the finished leather at one location. Awarded the EcoDesign Prize of the Federal Government, the Blue Angel Prize at the German Sustainability Award as well as the award as „Tannery of the year", HELLER-LEDER secures a successful existence under difficult conditions with innovative strength and constant struggle for the best solution for more environmental protection.

Website: www.heller-leder.com

The **Oeko-Institut** is one of Europe's leading independent research and consultancy organisations working for a sustainable future. Founded in 1977, it develops principles and strategies for realising the vision of sustainable development at global, national and local level. Based on value-oriented research, the Oeko-Institut provides consultancy services for decision-makers in politics, industry and civil society on topics such as Chemicals Management and Technology Assessment, Energy and Climate, Emission and Ambient Pollution Control, Radiation Protection, Agriculture and Biodiversity, Sustainable Consumption, Mobility, Resource Management and Industry, Nuclear Engineering and Facility Safety, and Law, Policy and Governance.
Website: www.oeko.de

Ökopartner Bildung . Beratung . Projekte organizes and accompanies educational projects and events that aim to support nature-compatible and equitable sustainable development.
Website: www.oekopartner-kiel.de

The **Schader-Stiftung** is a charitable foundation with seat in Darmstadt, Hesse. Its objective is to improve the dialogue between academia, in particular social sciences, and practice. The foundation is a partner in the project system innovation for sustainable development (s:ne), its task within the project is to build bridges and create opportunities for exchange. To this end, the foundation creates spaces for fruitful exchange through dialogue and transfer formats. The foundation, e.g., was involved in the planning and implementation of the Leather 2035 scenario process, a strategy workshop as well as various online formats.
Website: www.schader-stiftung.de

The **Schoenenkwartier** opened its doors on 28 June 2022 in a wing of the iconic Kropholler complex in Waalwijk, the Netherlands. With a new concept, this successor to the Dutch Leather and Shoe Museum aims to build a bridge between producers (both professionals and apprentices), the shoe industry and the public. In addition to three permanent exhibitions and one temporary exhibition, the concept includes five spaces for makers, designers and artists, the so-called ‚Maaklabs', a knowledge center with a depot for materials and a general educational space.
Website: www.schoenenkwartier.nl

Royal Smit & Zoon, founded in 1821, is an international family owned company that develops and manufactures sustainable bio-based chemical solutions for the leather industry. As a leading global supplier of specialty chemicals for leather manufacturers, the main focus is on sustainability through innovation and a long-term horizon to support customers in meeting their current- and future needs. Customers are active in industries such as automotive, high-end fashion, and upholstery. Royal Smit & Zoon is using three main brands, Smit, Codyeco and Nera. Their most recent addition is Zeology, the new standard in tanning and the truly sustainable alternative to existing leather tanning agents. Zeology is Chrome-free, heavy metal-free and aldehyde-free.
Website: www.smitzoon.com/en/

The **Society for Institutional Analysis (sofia)** is an interdisciplinary team of lawyers, economists and engineers to social and natural scientists, based at Darmstadt University of Applied Sciences (h_da). Sofia supports governance decisions aiming at sustainable development at all levels of society, including regulatory decisions of legislative bodies (European Commission, national or regional) The research group also analyzes and improves the strategies of public and private organizations.
Website: www.sofia-darmstadt.de

For more than 30 years, **SÜDWIND** has been committed to economic, social and ecological justice worldwide. Using concrete examples of grievances and problems, SÜDWIND uncovers unjust structures. In doing so, SÜDWIND combines research with development education and public relations work and carries demands into campaigns, society, academia, companies, and politics. SÜDWIND is a non-profit and independent organization. SÜDWIND is financed by grants, income from commissioned activities as well as membership fees and donations.
Website: www.suedwind-institut.de

The **Wuppertal Institute** is a research institute that develops concepts in the fields of energy, transport, resource use and climate policy as well as real-life visions of new well-being models. The division of 'Circular Economy', on the one hand, focuses on instruments, measures and policy mixes that contribute to the development of a resource-efficient circular economy. On the other hand, it conducts quantitative assessments measuring and monitoring sustainability paths on the national, regional as well as city level.
Website: www.wupperinst.org

Established in July 2020, The **Sustainable Leather Foundation**'s enables collective improvement and education globally, for more sustainable practices in leather manufacture and production, from raw material to finished product and post consumption. The Sustainable Leather Foundation is concerned with all aspects of sustainability – Environmental, Social and Governance. As a not-for-profit organisation, the Foundation provides an accessible, inclusive and modular approach to demonstrating sustainable good practice throughout the value chain using the SLF Transparency Dashboard™. Coupled with this, the Foundation is committed to ensuring that consumers have a clear mechanism to see and understand the sustainable attributes of leather as a material, and the work that the industry does to ensure good practice. The Foundation's objective is to bring together all leather value chain stakeholders to unite in ensuring a sustainable future for the leather industry by shining a spotlight on innovation and best practice, providing a mechanism for improvement and education, while also preserving the social and economic well-being of communities in less advanced regions. Working together is key to ensure that we can accelerate action.

VDL is The German Leather Industry Association e.V. (VDL), is a non-profit trade federation that represents and promotes the common interests of the leather producing industry. The tasks of the association are, among others, to represent the members nationally and internationally, to provide relevant information to the members, to take care of the community advertising for leather as well as of unfair competition law violations in the field of leather, to promote education and training, to support scientific and practical research in the field of the leather industry, and to do so objectively and without economic interests.

Website: www.vdl-web.de

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s:ne
SYSTEMINNOVATION FÜR
NACHHALTIGE ENTWICKLUNG