HOUDINI

Planetary Boundaries Assessment

2024

We can design our way of life within planetary boundaries. Imagine if we all did!

MOST THINGS ABOUT spending time in the great outdoors are great. That special combination of feeling on top of the world and humbled by its greatness. The beauty of lush forests, breathtaking views, ice and snow, skies and oceans. Those days of adventure and the joy of sharing them with friends.

But there are some things that we never asked for. Like toxic chemicals in our clothes. Like bad design contributing to waste streams and climate change. These things were not invented by outdoors lovers. They are the effects of companies cutting corners at the expense of eco systems, species and people. But it doesn't have to be this way. We can design our way of life within planetary boundaries. Imagine if we all did! Imagine if every business did!

The simple truth is, companies have the power to change course and leave predatory behaviors behind. Companies can phase out toxic chemicals in favor of planet-compatible alternatives, move from linear to circular and offer products that are built to last, rather than to be replaced. Companies can operate within the boundaries of our planet and by doing so, empower people to live within the boundaries of our planet, too.

Houdini has been on the journey to design its business to become a force for good since 2001. Our values and vision, coupled with the Planetary Boundaries-science provide direction, uncompromised commitment and speed. In 2015, we set out to assess our work using the Planetary Boundaries framework, in 2016 we drafted our 50-year roadmap towards regeneration and in 2018 we published a first Planetary Boundaries Assessment.

Meanwhile, the world has become more turbulent and difficult to predict. Our roadmap has been renamed into "trailmap", ast it better describes navigating this complex living system we are part of. We have expanded our perspectives on impact to include lifestyle, culture and consumption, we have measured impact where we can but we have also come to the conclusion that what matters the most can perhaps not be measured. It still requires our attention and it certainly has a place in an impact report.

Business within Planetary Boundaries is literally the escape act of our times and there is no time to waste. Let's make it happen, together.

/The Houdini Team

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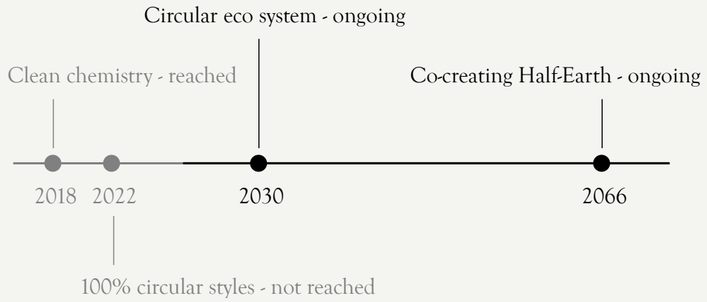
2016-2066

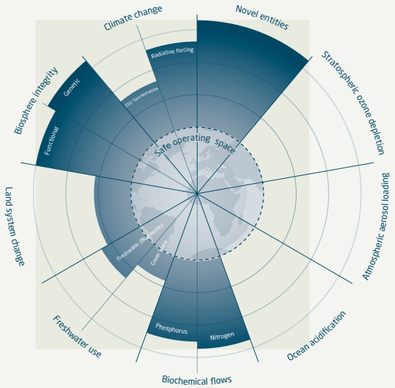


Houdini trailmap towards Half-Earth, a world in harmony with nature where all life can prosper.

DEEP ECOLOGY

The philosophy that form keel and rudder throughout Houdini operations.

PLANETARY BOUNDARIES



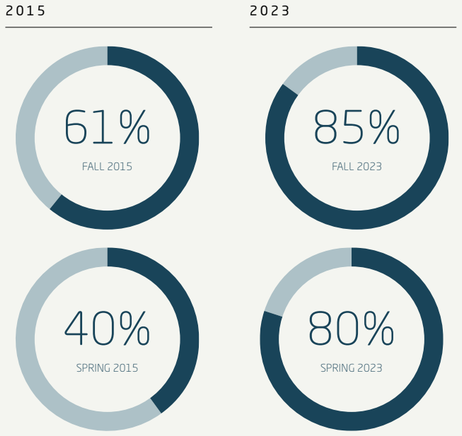
The science-based framework that guides Houdini forward to nature.

IMPACT FORMULA

$$P \times V + L = I$$

The holistic corporate impact formula applied by Houdini.

CIRCULAR STYLES



Houdini's advancement in share of circular styles from 2015 to 2023.

CIRULAR SUBSTITUTION

79%

Share of fabrics substituted

Share of substituted fabrics and technologies to achieve increase in circular products

POST CUSTOMER CARE

0

No precious natural resources wasted

Taking full producer's responsibility with Houdini Recycle since 2007

RELATIONAL VALUE CHAIN

71

Supplier partners

Genuine relations with a selected few supplier partners - from fabrics, technologies and trims to manufacturing - a prerequisite for transformation

EVERYTHING MATTERS

:) : | : (

Everything matters in the process of transformation, whether possible to assess in numbers or not.

EVERAGE USE: **1287 TIMES**

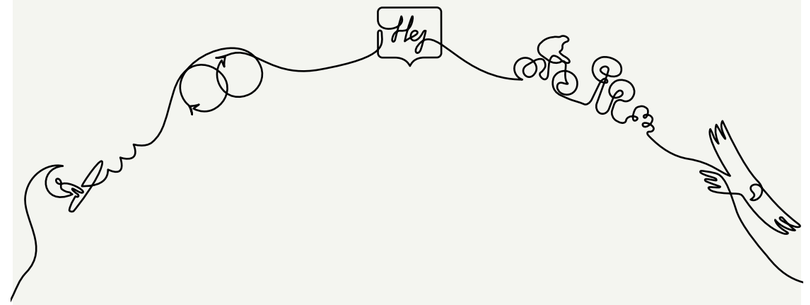
Average times of use for a Houdini product vs. global average times of use for a garment. Over 10 years of use, several times per week, for multiple activities.

LIVE LARGE WITH LESS

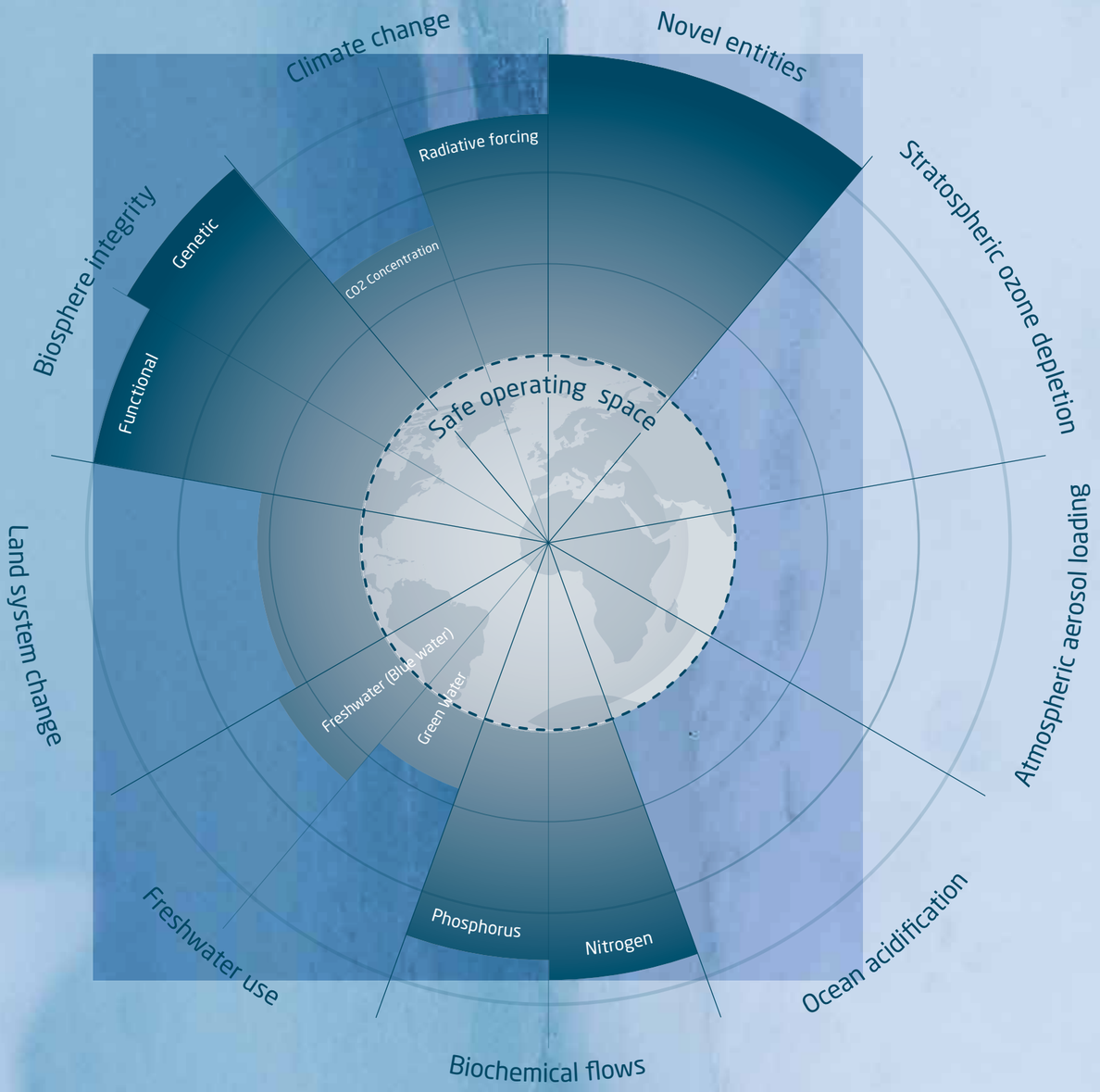
15 Garments	12 Months	31 Ski touring days
18 Camp nights	41 Kayaking trips	2 Weddings
5023 Biking (km)	173 Office days	11 Music festival days

One individual's statistics in the #LiveLargeWithLess challenge.

LIFE CENTRIC BUSINESS



Shaping business in harmony with nature in a counter-action to the machine-centric system shaping business today.



Business within Planetary Boundaries – the escape act of our times.

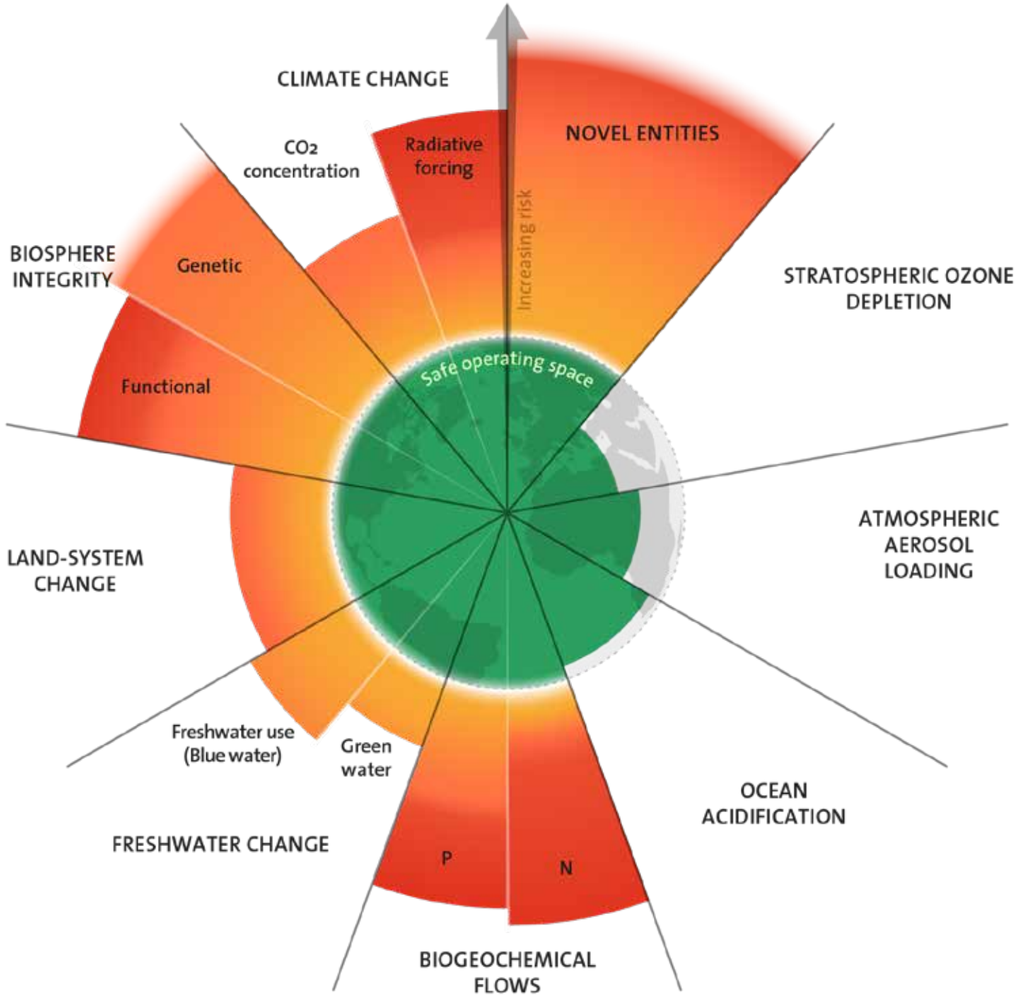
Companies need a holistic and in-depth understanding of the earth system.

Planetary Boundaries – an essential framework for business

FOR BUSINESS TO OPERATE within the boundaries of our planet, companies need a holistic and in-depth understanding of the Earth-system, its complexity and entangledment as well as how their operations impact the respective boundaries and the system in its entirety. Impacts not only on climate, but on biodiversity, oceans and fresh water, land-systems and every other planetary boundary need to be acknowledged, understood and addressed.

The Planetary Boundaries framework provides such a systems perspective. It provides insight in negative impacts that need to be mitigated as well as positive impacts to ithat can be scaled. It provides foresight about risks and opportunities and guides towards science-based action.

The framework can help companies steer towards business within planetary boundaries and an era of corporate stewardship of life on Earth.

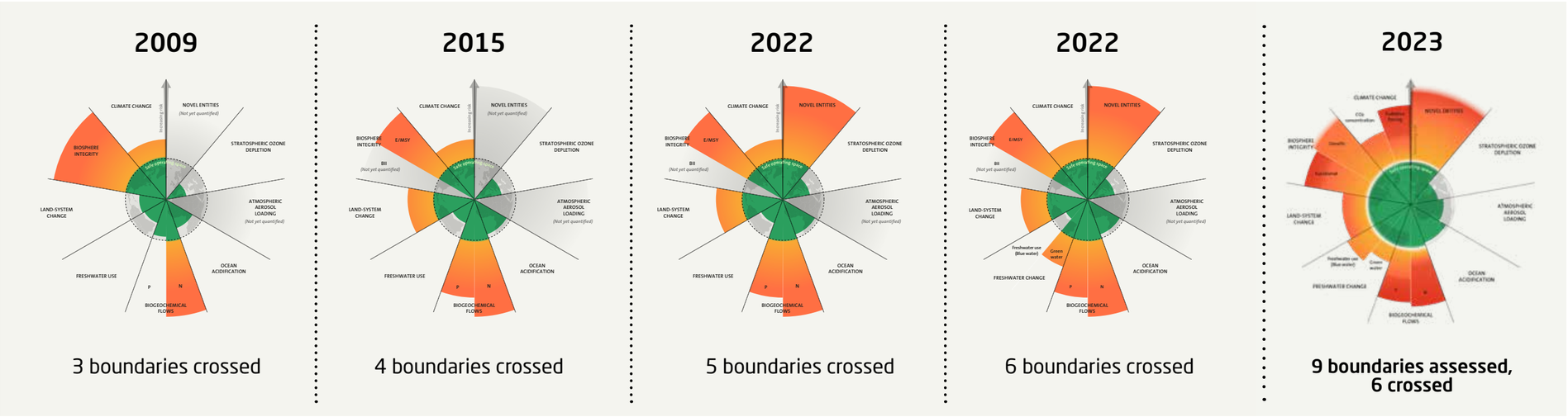


The Planetary Boundaries – an essential framework for business. Originally developed by earth system scientists, Rockström et al, in 2009 and initially applied to business by Houdini in 2015.

The state of our planet – the 2023 update

IN SEPTEMBER of 2023, earth system scientists published the latest Planetary Boundaries update to check the health of our planet. It was the first time all nine planetary boundaries could be assessed, and researchers concluded that an alarming six out of nine boundaries had been crossed. This does not equate to drastic changes happening overnight, but it marks a critical condition and increasing risks to people, the ecosystems we depend on and life on Earth as we know it. With the exception of the Stratospheric Ozone Boundary, where things are actually improving, we are moving in the wrong direction for all boundaries.
The reasons that more boundaries have been crossed since the last update, are both increased human pressures on the planet and improved scientific evidence of the state of the boundaries. For instance, the Novel Entities Boundary was most likely crossed already before the first Planetary Boundaries paper was published in 2009, but there was not enough data and scientific consensus to draw that conclusion at the time.

The world is moving in the wrong direction in eight out of nine boundaries.



Companies have the power to change course and operate within planetary boundaries.
Imagine if every business did.

How can we support a mind shift where businesses become custodians and consumers turn caretakers?

Design thinking for a living system

THE TRAJECTORY THE WORLD is still on raises questions. The Planetary Boundaries science has been available since more than a decade and numerous sustainability initiatives, commitments and reports have been launched during the same period. How come we are failing to address the largest threat humanity has faced in modern times? There are clearly systems structures holding the transformation back but is mindset and culture holding us back too? And in that case, how can we support a mind shift where businesses become custodians of resources and its consumers turn caretakers?

Based on questions like these and key findings from the 2018 Planetary Boundaries Assessment and conclusions from Houdini's 2020 white paper Regenerative Lifestyle Initiative, co-authored with Dennis Pamlin and Hedström, Houdini has doubled down on its efforts to influence consumption, culture, values and lifestyle.

Inspired by the environmental scientist and systems thinker Donella Meadows' design thinking for living systems, the company has explored how to support a shift away from today's consumer culture and disconnect from nature. Houdini's commitment to its purpose, to 'Reconnect to nature', has been reinforced and several initiatives added to Houdini's impact agenda, complementing its well-established work on circular materials on its jounrey towards Planetary Boundaries-compatible resource-use.

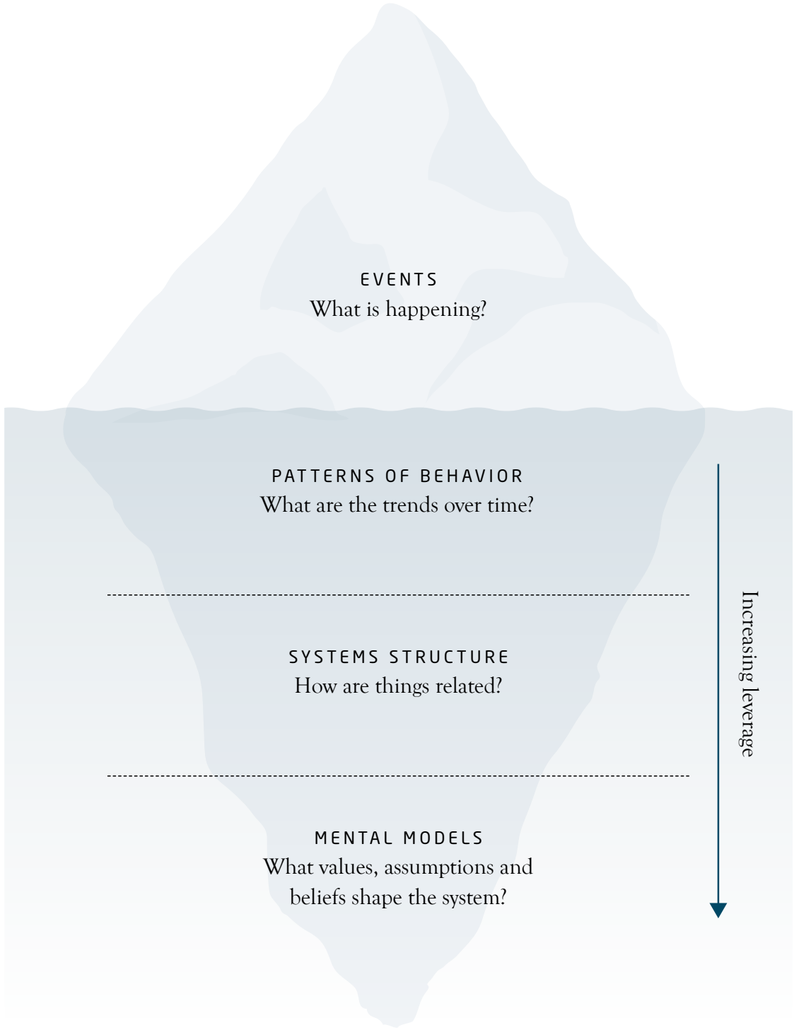


Fig. The Iceberg model by Donella Meadows.

Volume

Impact

$$P \times V + L = I$$

Product

Life

Houdini has introduced a corporate impact formula, P * V + L = I, that similar to Donella Meadows Iceberg model, takes a whole systems perspective on corporate impact. It can be applied both to identify and scale positive impacts and to reduce negative impacts. With this perspective a company is accountable for volumes produced and wardrobes enabled (V) as well as corporate life lived and lifestyle promoted (L) in addition to product design and production(P) in its impact work. Had the formula been applied broadly in the apparel industry, planetary impact would have been radically reduced, since over-production is massive and lifestyles promoted questionable within a significant portion of the industry.

Houdini has engaged with its users to assess whether its product design has had intended effects on product lifetime and user behaviour. It has invested in business model innovation to empower its customers and users to go circular and designed communications campaigns and collaborations to inspire product care, to live large with less and to reconnect to nature. Furthermore, new partnerships have been forged and advocacy become an integral part of Houdini's work.

THE HEALTH OF OUR PLANET'S biosphere depends on thriving and resilient natural ecosystems. All over the world ecosystems are threatened by the accelerating demand for natural resources and the accumulation of waste caused by linear practices. The critical transition from fast, linear and wasteful to slow, circular and waste free is one of the most effective strategies to get back within 'safe operating pace' of the Planetary Boundaries. If done properly at systems level, circular design has positive effects on all nine boundaries.

With nature as its blueprint, Houdini has designed its entire ecosystem to be circular. By caring for, reusing, remaking and circulating resources, Houdini aims to eliminate the use of finite resources extracted from the earth's crust, with the ultimate goal of allowing the planet, its ecosystems, humans and our fellow species to heal and thrive.

ALL SECTORS

The critical transition from fast, linear and wasteful to slow, circular and waste free is one of the most effective strategies to get back within planetary boundaries.

Circularity can only be achieved if it is an integral part of the design process

DESIGN PRINCIPLES

1. Less is more – wearable multitools and minimalist designs
2. Built to last – both in terms of quality and style.
3. Holistic comfort – embracing individuality, all senses, body, mind and soul.
4. Circular – with nature as our blueprint.

Design principles and Checklist

IT ALL STARTS WITH design. Houdini's holistic design principles ensure that products are designed according to circular principles, that they deliver without compromise during the entire user-phase and that product lifetime is extended to the maximum. Products are kept in use and circulation through services such as care, repair, reboot, share, reuse and remake before being recycled.

Taking full producer responsibility

HOUDINI'S DESIGN PRINCIPLES are not isolated to product design but applies holistically throughout the product lifetime, including next-life solutions. A circular take-back system is in place since 2007, enabling Houdini to collect, sort, store and recycle its material resources at the purest level. The current eco system of recycling partners enable 85% of Houdini products to be recycled. In the few cases where proper recycling technologies are not yet at industrial scale, Houdini stores worn-outs until a viable alternative is available and has done so since 2007. This might well be a unique example of taking full producer responsibility for the company's use of material resources.

DESIGN CHECKLIST

Does this product deserve existence?
Will it last long enough?
Is it versatile enough?
Will it age with beauty?
Nothing added that isn't needed, right?
Is it fit for sharing, reparing, remaking and reselling?
Does it have a next-life solution?

The Rollercoaster shell layer - waste-free by design.

ALL SECTORS

Designing for circular material flows

HOUDINI STRIVES TOWARDS mono material design, either in the technical or the biological cycle. Raw material technologies of the two different cycles are kept apart in both fibers, fabrics and final products so that both can be recycled with quality maintained, enabling next-life solutions at the same high level of quality and performance.

For an overview of circular principles for product and raw material flows, see the “butterfly infographics” from the Ellen MacArthur Foundation, 2019.

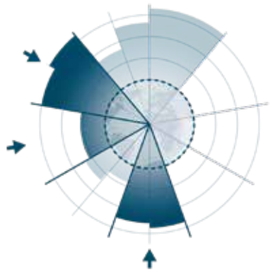
The technical material cycle

THE CIRCULAR FLOW OF technical materials is an example of biomimicry, innovation inspired by nature. Much like in nature, once recycled fibers become building blocks for something new.

The Rollercoaster shell layer is one example. It is a fully featured freeride and ski touring shell layer, featuring Houdini’s soft, supple and silent 3-layer waterproof and breathable mono material technology. The Rollercoaster is built to last, both in terms of quality and style. It is designed for hardcore use and easy care and repair. When the Rollercoaster eventually wears out, the recycled and recyclable mono-material fabrics can circle back into the system and become building blocks for a next generation of mono-material garments. Waste-free by design.

Houdini Menu, a collab with soil microbes and a fine dining chef.

BIOSPHERE INTEGRITY
LAND SYSTEM CHANGE
BIOGEOCHEMICAL FLOWS



Products in the biological material cycle

HOUDINI'S CIRCULAR FLOW of biological materials is an example of how Houdini goes beyond biomimicry towards a state of symbiosis with nature. Fibers with their origin in the natural world, such as merino wool and lyocell, are turned into beautiful yarns, fabrics and garments with their natural intelligence and purity kept intact. No synthetic fibers, chemistry or treatments are allowed into the mix.

By nature, the garments provide natural performance in perfect symbiosis with skin, body, layering system and the outside conditions. When fibers from these garments end up in nature, they forge partnerships with soil microbes and turn into nutrients. With a little human ingenuity, natural fibers can be cared for and recycled into new garments before they are returned to nature, which is why naturals are included in Houdini's take-back system.

Houdini Menu

IN AN ONGOING PARTNERSHIP with composting and permaculture experts, Houdini field-tests every biologic fabric developed to ensure their symbiotic relationship to nature. The Houdini compost can be visited at Rosendals Trädgård in Stockholm, a short boat-ride from the Houdini head quarters.

After the first composting field-test was performed in 2016 and organic vegetables and herbs had been grown in soil from the compost, Houdini decided to celebrate the beauty of working in partnership with nature. It invited its customers to a fine dining experience, where a chef had created a fine dining menu from the vegetables and herbs grown in the composted merino baselayers. The Houdini Menu was born.

Increase in share of circular styles within Houdini's product line.

ALL SECTORS

Share of circular styles

PRODUCTS THAT ARE CIRCULAR by design is a foundational strategy on the journey towards business within planetary boundaries, it is a key performance indicator for a circular ecosystem. Houdini's definition of circular is either made from recycled and recyclable fibers or made from renewable and biodegradable fibers.

For the critical transition from linear to circular, a staggering 79% of Houdini's fabrics and technologies have been substituted. Alternatives have not always been readily available, which has resulted in material development- and innovation processes. Houdini's design principles and its practice of the precautionary principle has provided the framework. In addition to substitution, there have been cases where suitable alternatives were not found, resulting in the cancellation of entire product series.

These graphs show Houdini's advancement in share of circular styles comparing 2015, the basis for the first Planetary Boundaries Assessment to 2023, the basis for this assessment.

A critical addition to share of circular styles, Houdini measures share of circular raw materials used in yearly production. This, in order to analyze both global and regional planetary impacts as well as to follow market adoption.

2015

2023

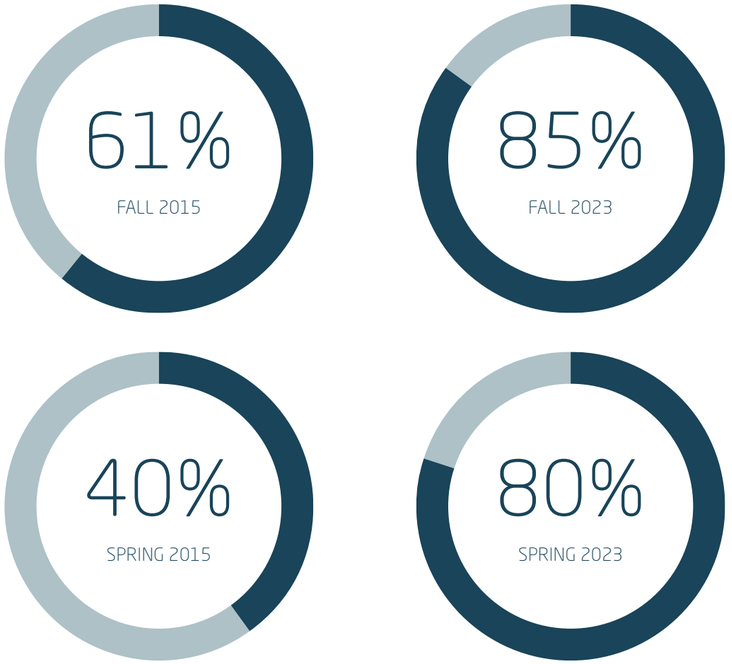


Fig. Houdini's advancement in share of circular styles from 2015 to 2023.

Increase in share of circular materials used

ALL SECTORS

FIBER USE - FALL 2014 / SPRING 2015

Merino Wool 4,6% **Wool** 0,13% **Recycled Polyester Mechanical** 12,94% **Virgin Polyester** 33,55% **PTT** 1,43% **Kevlar** 0,08%
Lamb's wool 0,69% **Silk** 1,36% **Recycled Polyester Chemica** 20,63%l **Polyamide** 20,23% **Elastane** 4,92%

FIBER USE - SPRING 2023 / FALL 2023

+ **Lyocell Tencel** 7,34% **Recycled Polyester Mechanical** 38,34% **Virgin Polyester** 26,64% **PTT** 0,04% **Kevlar** 0,03%
Merino Wool 3,37% **Recycled Polyester Chemica** 1,98% **Polyamide** 15,74% **Elastane** 4,10%
Lamb's wool 0,39% + **Recycled Polyamide** 0,60% + **Elastomultiester** 1,37% + **Polyurethane** 0,05%

Share of circular materials

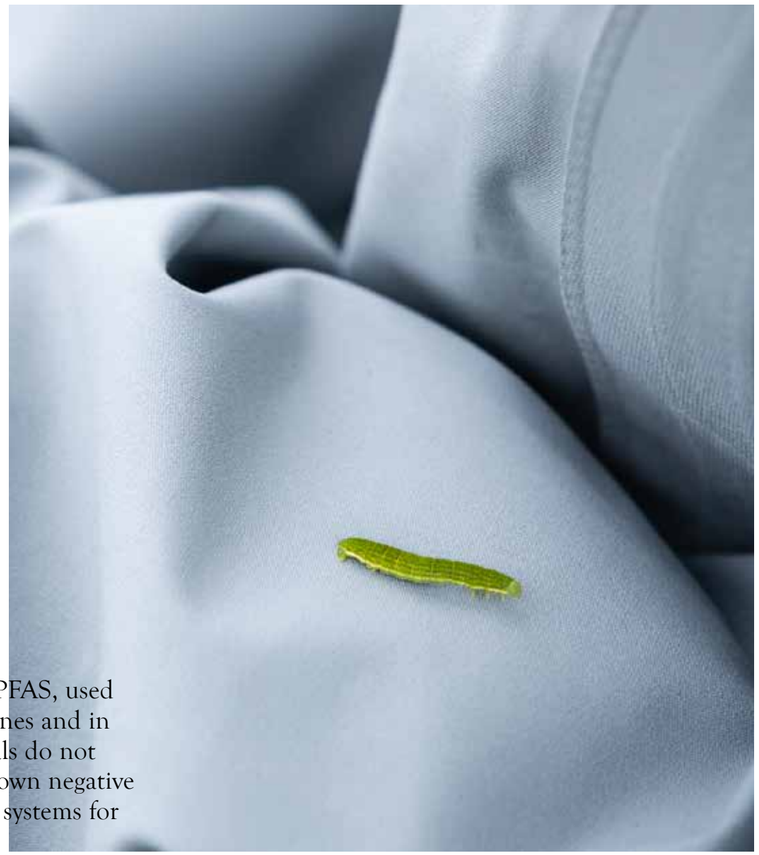
THESE GRAPHS SHOW Houdini's advancement in kg of yearly material consumption, comparing 2015, the basis for the first Planetary Boundaries Assessment to 2023, the basis for this assessment.

The share of Houdini Menu-level fibers used has almost doubled. This increase in share of circular fibres within the biological cycle well reflects that market adoption has been in line with Houdini's strategic shift in product range.

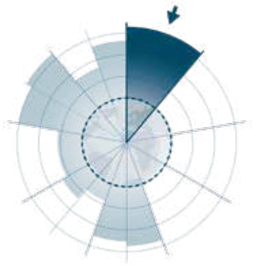
The increase in share of recycled fibers within the technical cycle has been more challenging. The share of virgin polyester, polyamide, and elastane have decreased, but not to the extent Houdini had aimed for. This does not reflect Houdini's ambition, which is to phase out virgin fibers entirely, nor does it reflect what is technologically possible. This is rather an effect of the inaction at systems level where pricing structures, policy and regulations benefit the fossil and extractive economy, radically limiting opportunities for sustainable alternatives to take market share. The increased share of mechanically recycled polyester at the expense of chemically recycled polyester is partly a dent in the curve due to a temporary upgrade in technology for chemical recycling, but it also reflects how textile-to-textile recycling has not yet taken off to the same extent as PET-bottle recycling has.

Important to underline is that the slow speed in transition and inaction at systems level, is also an effect of the industry's reluctance to move before regulations forces it to. This status-quo at systems level makes it difficult even for frontrunners to fully transition.

In line with its precautionary principle, Houdini never used PFAS-based membranes and has been entirely PFAS-free since 2018.



NOVEL ENTITIES



Taking action on chemical pollution

FOR NOVEL ENTITIES, chemical pollution, including micro plastics and hazardous substances like PFAS, is one of the most recent boundaries to be quantified and assessed. The world most likely crossed it long before the first planetary boundaries paper was published.

Chemical pollution causes large-scale disturbances in ecosystems and species, including humans, worldwide. In addition, there is limited knowledge of the long-term and combined effects of these chemical substances. Although the heavy use of hazardous chemicals in apparel has continued until today, alternative chemistry and emerging regulation provide solutions and hope.

Houdini's ambition is to practice the precautionary principle, and its "clean performance" policy has lead the company to create its own "restricted substances list" (RSL). This has resulted in the substitution and phase-out of both fabrics and chemical treatments as well as innovation partnerships to develop alternatives.

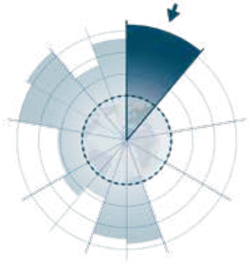
Houdini's phase-out of PFAS

ONE SUCH GROUP OF hazardous chemicals is PFAS, used in certain waterproof/breathable membranes and in water repellent treatments. These chemicals do not break down, are carcinogenic and have shown negative effects on both reproductive and immune systems for humans and animals.

In line with its RSL and precautionary principle, Houdini never used the dominant membrane featuring this chemistry. For the same reason, Houdini was one of the first brands to initiate a complete phase-out of PFAS. In 2018, after an intense DWR substitution process, Houdini's entire product line, including its waterproof/breathable outerwear, were 100% PFAS-free.

Taking on wicked problems sparks critical innovation.

NOVEL ENTITIES



Towards zero release of microplastics

SIMILAR TO ITS RSL, Houdini has defined its internal list of Restricted Fabric Technologies on its journey towards zero release of microplastics. In addition to phasing out entire product groups in accordance with this list, such as conventional brushed fleece, Houdini has undertaken a number of measures to minimize microfiber shedding and participated in various innovation projects on the subject.

Several shedding-free alternatives have been developed, spanning from Cloud9 (C9), a highly technical synthetic alternative constructed of air-permeable filament fiber fabrics with encapsulated mono-material paddings, to thermal layers made from pure fibers for biological cycle.

Collaborative innovation in Project Mono Air

IN THE MONO AIR PROJECT, Houdini and Polartec set out to explore pathways towards shedding free thermal layers. In 2020 they launched a pioneering thermal fabric technology engineered specifically to prevent microplastic pollution from microfiber shedding. The material innovation was the first in a series of fabrics that have since been launched. In addition to significantly reducing microfiber shedding, the Mono Air technologies deliver benefits beyond microplastics in terms of circularity, layering comfort and dry time.

Taking on wicked problems, ultimately sparks innovation that solves more than what was originally intended. The Mono Air Project is a great example.

A highly selective partnership strategy, with longterm relations

ALL SECTORS

A value chain for holistic value creation

A FEW CHARACTERISTICS of the Houdini value chain stand out: Its relational and collaborative character, the limited number of suppliers in total, with a large share located in high income countries, the high level of granularity with traceability and sharing of knowledge.

Houdini's supplier partners, a carefully selected few world leading fabrics, trims and technology suppliers and garment manufacturers, amount to less than 71, which can be compared to around 1000-2000 suppliers in a typical business within the apparel sector. Apart from being leaders in their respective fields, their commitment knowledge-sharing and cross-pollination of ideas as well as the highest social, ethical and environmental standards is a prerequisite. Houdini relies on their collaboration to succeed with the transition towards circular and regenerative and forge genuine long-term relations where trust is cultivated and long-term goals are set in partnership.

Houdini engages with its supplier partners to tier 4 for all main materials as well as for manufacturing and tier 3 for trims, with the ambition of providing full traceability and transparency.

GARMENT ORIGIN SPRING/SUMMER 2023

Portugal 40% **Latvia** 23% **China** 3%
Lithuania 24% **Estonia** 10%

GARMENT ORIGIN WINTER/FALL 2023

Portugal 15% **Latvia** 33% **China** 3% **Poland** 4%
Lithuania 14% **Estonia** 22% **Vietnam** 9%

FABRIC ORIGIN SPRING/SUMMER 2023

Japan 38% **Taiwan** 15% **Lithuania** 8% **China** 3%
Italy 17% **USA** 12% **Sweden** 7%

FABRIC ORIGIN WINTER/FALL 2023

Japan 27% **Taiwan** 7% **Lithuania** 7% **China** 5%
Italy 23% **USA** 10% **Sweden** 20% **Vietnam** 1%

Independent of the location a high standard of social sustainability following the Houdini code of conduct and framework.

Alto Half Zip value chain, examplifying how Houdini nominates every component of a garment – from fiber and fabric, to zippers, sewing tread and labels.

Manufacturing: Marbäck Latvia (Amfori Social Audit rating A)
Main fabric: Marbäck Sweden
Fabric details: Marbäck Sweden
Knitting: Marbäck Sweden (Oekotex certified)
Dying: Marbäck Sweden (Oekotex certified)
Finishing: Marbäck Sweden (GOTS certified)
Yarn: Südwolle Germany (Naturetexx Plasma, GOTS & Bluesign certified)

Washing and combing: Südwolle China (GOTS & Oekotex certified)
Raw material: Merino Wool Australia (AME traceable)
Farms: 6 farms in Tasmania (selected AME)

Zip puller: ACG China (traceable and certified)
Logo tab: ACG China (traceable and certified)
Woven size label: ACG China (traceable and certified)
Hangtags: ACG Sweden (traceable and certified)
Thread: Coats Europe (traceable and certified)
Care label: Nilörn UK (traceable and certified)
Zipper: YKK Taiwan (traceable and certified)

Fiber: TENCEL Lyocell Lenzing Austria (EU Ecolabel)
Raw material: Lenzing Europe (FSC certified)

ALL SECTORS

Good product design can transform the entire apparel system from linear, fast and wasteful to circular, slow and waste free.

Product design for a circular user-phase

ONE OF THE MAIN CONCLUSIONS of Houdini's 2018 Planetary Boundaries Assessment was that designing for longevity reduces negative impacts on all boundaries. One year later, Houdini conducted a survey with over 400 Power Houdi users, revealing that the average number of times this iconic Houdini style is worn amounts to 1287 times. More than 10 years of use, several days per week and for a multitude of different activities. In contrast, the global garment average is 120 and as low as 10 in some parts of modern society.

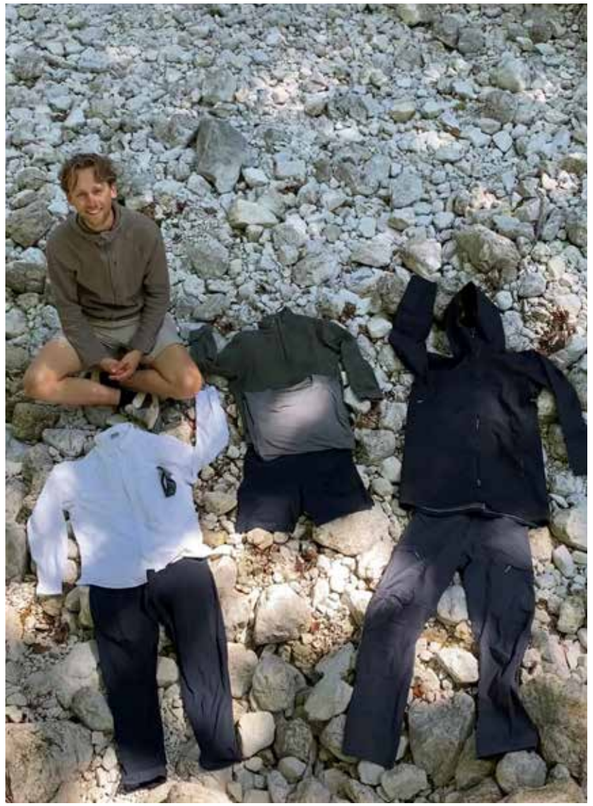
Considering the current state of the global apparel system, where a 100 billion garments are produced each year and 60% is discarded within the first year, the case for addressing products (P) not only from a circular materials perspective but from a volumes (V) and lifestyles (L) perspective is strong. Good product design can radically extend product lifetime, promote circular use and transform the entire apparel system from linear, fast and wasteful to circular, slow and waste free.

HOUDINI: 1287 TIMES

GLOBAL: 120 TIMES

LOCAL: 10 TIMES

HOUDINI GARMENTS
15



#WEDDINGS
2 TIMES

#ROAD CYCLING
5023 KM

#SKITOURING
31 TIMES

#KAYAKING
41 TIMES

#TRAIN TRAVEL
7500 KM

#CAMPING
18 TIMES

Empowering people to Live Large With Less

IN 2021 HOUDINI LAUNCHED the #LiveLargeWithLess challenge, a communications campaign designed to encourage its audience to select a wardrobe of only 10 garments for their entire summer. The challenge, which was featured in social media went viral and resulted in many taking on the challenge and many more to reflect on their size of wardrobe and their actual needs for a "live large" way of life. Three years later the initiative has created ripples and become an integral part of Houdini's communication.

A diverse group of people from across the globe have shared their #LiveLargeWithLess experiences in Houdini channels. One of them, Gustav Hedström, Business Analyst at Houdini HQ, has taken the challenge further, applying his analytical skills to assess the impact of his wardrobe and lifestyle. Here is a glimpse into his #LiveLargeWithLess way of life.

Houdini believes in cross-pollination and interdiciplinary collaboration.

ALL SECTORS

Circular innovation for the future

HOUDINI MIGHT BE on a good trajectory, but in order to reach its vision, to operate in symbiosis with nature, radical work remains to be done. Hence, the company continues to innovate their way towards business within planetary boundaries.

More importantly, the trajectory the world is currently on, leads towards uncharted territory and potential collapse. Hence, the corporate sector needs to acknowledge its responsibility and opportunity, act on the science and collectively change course. And it needs to do it with great commitment and speed, starting today.

With the sense of urgency and abundant value in moving to a symbiotic state, Houdini's innovation projects span its entire ecosystem - from material technologies, product design and manufacturing to business models, product maintenance and systems design.

Houdini believes in cross-pollination and interdisciplinary collaboration across sectors and often partner up with likeminded independent of sector, in search for superior solutions to our common challenges.

Connecting product, user and maker to support a circular user-phase

IN 2021 HOUDINI INITIATED a collaborative IoT project exploring the question: Could a digital bond between product, user and maker form circular habits that do good for people, planet and business? Could shining a light on positive actions rather than carbon accounting support a mindshift and change in behavior? Could a digital experience be designed to not stand in the way of reconnecting to nature?

These were the fundamental questions that Houdini in partership with EON, Prototype and One Day Interact set out to explore. At the time Houdini was one of the first brands to explore the emerging opportunities with IoT solutions for apparel. Today product passports have become a reality and perhaps soon a requirement. The digital ID:s can provide in-depth information at point of purchase, lower the threshold for care, repair and resale. With individual digital ID:s, garments can be connected, managed and stewarded throughout their lifetimes, making them better equipped for rental, subscription and recycling eco systems as well as to support individual users with wardrobe and lifestyle data.

In the first pilot, users could connect their garment to their smart phone and log its life and adventures. A mountain climbed, time spent in nature, bike-commutes to work, peer-to-peer sharing and more generated data points and a lifeline illustrating its circular life and adventures.

To what extent Connected Products can encourage product care, a higher frequency of use, an active way of life and a mind shift from consumer to caretaker is yet to be assessed. Shining a light on individuals' positive impacts rather than counting their negatives was an active choice. Houdini believes the responsibility to eliminate negative impacts lies with companies and governments rather than people.

Houdini Circle - seamless, circular and user-centric.

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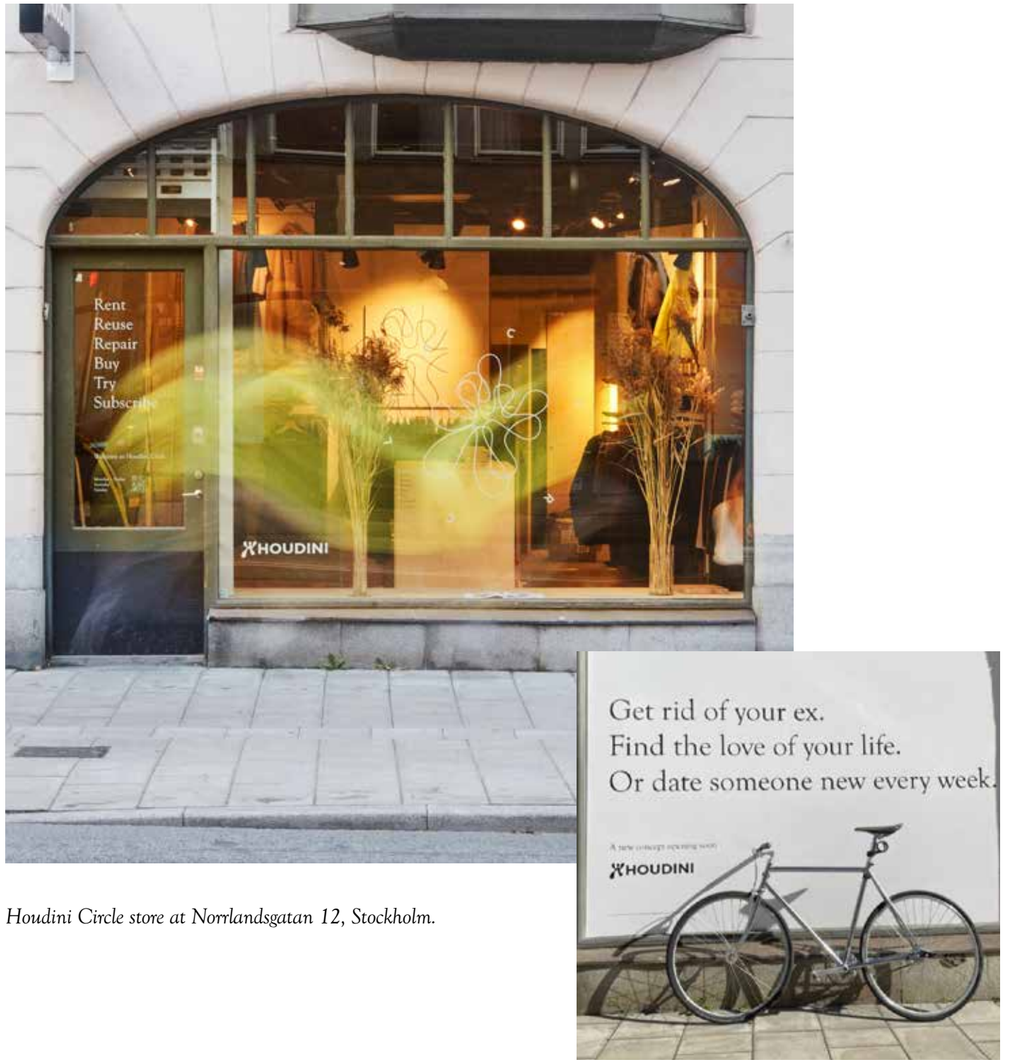
Business model innovation for a circular user-phase

AS A PIONEER IN THE EMERGING circular economy, Houdini has extensive experience in business model innovation, including access-based business models to provide its customers with alternatives to ownership and services to support its users to extend the lifetime of their Houdini and provide next-life solutions for when they eventually have worn out.

In its latest initiative, Houdini Circle, Houdini is attempting to create a seamless, circular and user-centric eco system where all its services and business models have been merged into one circular universe. Customers can buy, rent or subscribe to everything within the Circle, ranging from new, to reuse and remake garments, including well-worn repaired garments and exclusive remake pieces. In addition the Circle provides access to workshops, experiences and made-to-order exclusives. The become part of the reuse marketplace designed for buying, selling and sharing used Houdini gear and get support with care, repairs, remake and recycling.

The concept is under development in an iterative process and is anticipated to become a cornerstone in Houdini's retail ecosystem globally.



Houdini Circle store at Norrlandsgatan 12, Stockholm.

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Collaboration and Open Source to go further faster.

IF INITIATIVES SUCH AS Connected Products and Houdini Circle prove to drive change, it wouldn't be the first time a major upgrade in product or retail experience comes with a significant reduction in planetary impact. It is yet another example of our capacity for meaningful collaborative innovation, when stakes are high and compromise is not an option.

But sustainable innovation makes little sense if solutions are kept exclusive instead of being shared. By collaborating and practicing Open Source we can go further, faster. This Planetary Boundaries Assessment is a collaborative effort in itself. It would not have been possible without the brilliance of earth system scientists at Albaeco and The Stockholm Resilience Center.

Let us share progress, scale solutions and collaboratively pivot from the old and embrace the new. It is time to gracefully let linear technologies and outdated business practices go, to help save species and life as we know it. This is our chance. Let's not blow it.

To quote the late E.O. Wilson: 'We can share this precious planet of ours. All life could prosper. It would be humanity's greatest achievement.'

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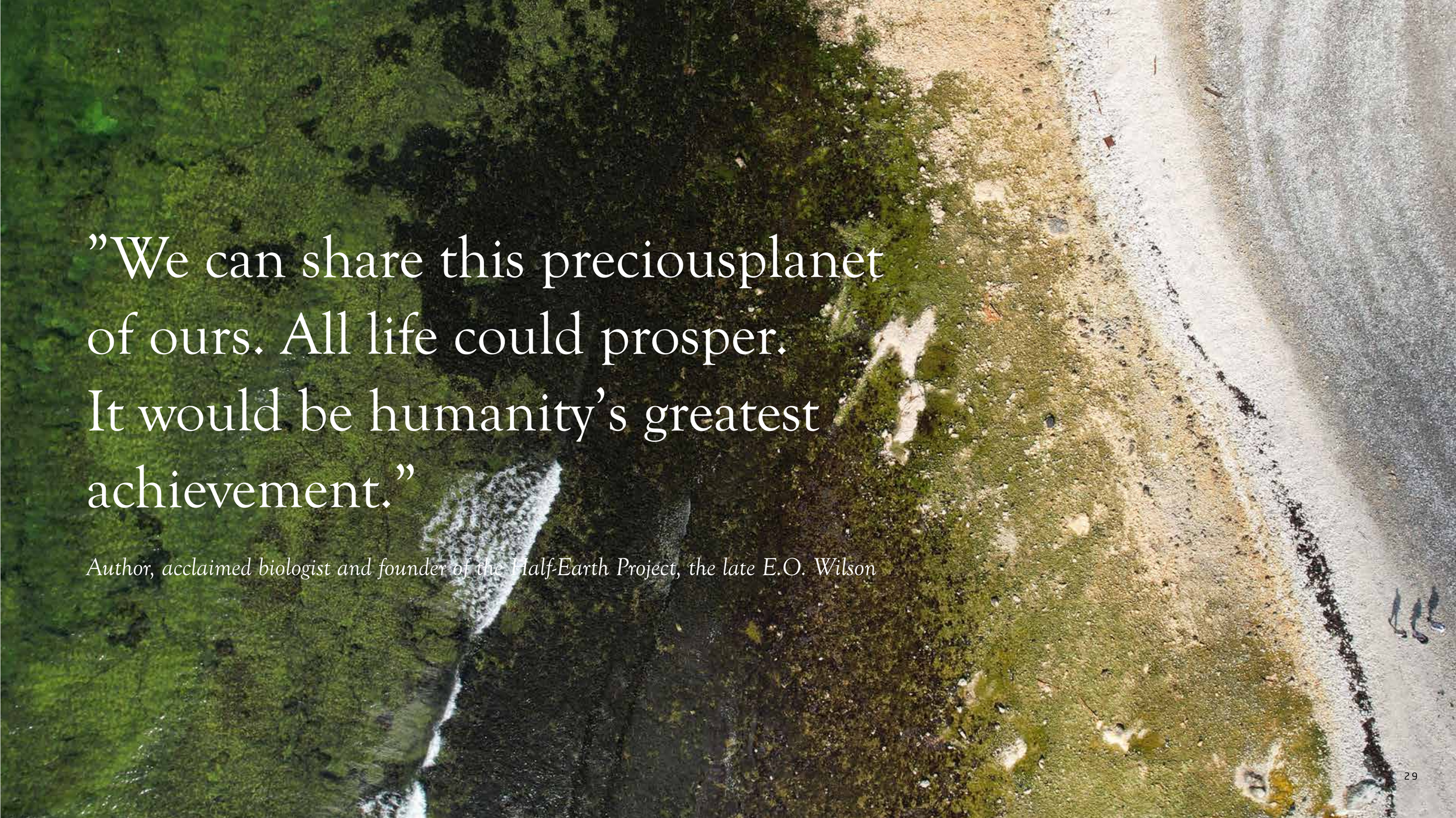


”We can share this preciousplanet of ours. All life could prosper. It would be humanity’s greatest achievement.”

Author, acclaimed biologist and founder of the Half-Earth Project, the late E.O. Wilson

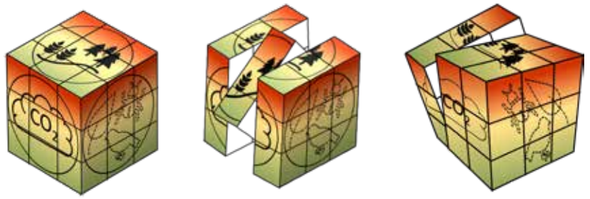
1. Introduction

THE EARTH WE LIVE ON and the world we live in are inextricably interconnected – though we might not always see the connections very clearly (e.g. Folke and others, 2021). In the urbanised and globalised world a decreasing share of the world's population directly experience their fundamental dependence on Earth's natural systems on a daily basis – yet everyone everywhere relies on natural ecosystems and the services they produce, for a stable climate, the food we eat, the clothes we wear, and many other resources we use in our daily lives. Today it is also a fact that all ecosystems on Earth have been affected and shaped by people (e.g. IPCC 2022). Scientists have found that the human impact on the planet is so profound that we have already crossed several planetary boundaries (Steffen and others, 2015; Richardson and others, 2023) and are entering an entirely new phase of planetary history: the Anthropocene, the age of humans (Zalasiewicz and others, 2021).

In 2018 Houdini Sportswear and Albaeco, with contributions from Mistra Future Fashion, launched the first ever corporate sustainability report based on the holistic Planetary Boundaries framework. It was an important step towards understanding Houdini's impact on the world, and gained a lot of attention in the textile industry and beyond. The assessment of Houdini's impact was based on nine planetary boundaries for: Climate change; Biodiversity; Land Use change; Novel entities; Ocean acidification; Nutrient loading; Ozone; Aerosols; and Water.

The Planetary Boundaries is a research framework that illustrates the safe operating space for humanity and the boundaries within which the Earth's biosphere and climate can deliver the goods and services humanity depends on (Rockström and others, 2009). For climate change, carbon dioxide levels should not rise above 350 parts per million (ppm) in the atmosphere if we are to remain in the "safe operating space" of planetary boundaries. This would be consistent with a stabilisation of global temperatures at about 1.5 degrees Celsius above pre-industrial levels, but this boundary and at least five others have already been crossed. Taking a planetary boundaries approach in environmental impact assessments is therefore more urgent than ever before, but it comes with a number of challenges.

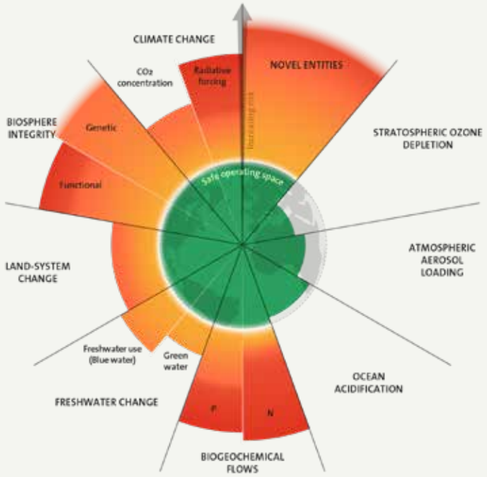
Widening one's focus to see impact across a breadth of ecosystems and scales lowers the risks of overlooking important aspects and of implementing "fixes" to environmental impact in one area, e.g. emissions of greenhouse gases, at the expense of negative outcomes in others, like biodiversity and land use. Researchers at the Stockholm Resilience Centre have used the analogy of a Rubik's cube to describe the necessity of dealing with such complexity: if we focus only on one planetary boundary (one side of the cube) we risk messing up the rest (see below).



Houdini has since 2018 continued to use the Planetary Boundaries framework to understand the impact of their operations and to prioritise their policies. Their stated mission is to not just limit the negative impact on the planet, but to have a long term positive influence. The Planetary Boundaries Assessment is a key foundation for that ambition.

Planetary Boundaries - more than climate

IN 2009 AN INTERNATIONAL group of 29 internationally renowned scientists identified nine planetary boundaries we should remain within so that our societies can continue to develop in a positive way – without facing catastrophic threshold effects in the global environment and climate (Rockström and others 2009). The analysis was updated by Steffen and others in 2015, concluding that four of the nine boundaries had been crossed as a result of human activity. According to updates in 2022 (Persson and others, 2022; Wang-Erlandsson and others, 2022) and 2023 (Richardson and others, 2023) a fifth and sixth boundary have also been transgressed (red/orange). The six are: climate change, loss of biosphere integrity (ecosystems and biodiversity), land-system change (e.g. deforestation), altered biogeochemical cycles (phosphorus and nitrogen pollution), novel entities (chemical pollution, plastics etc), and "green" and "blue" freshwater flows. Other boundary processes included in the analyses were: stratospheric ozone depletion, alteration of atmospheric aerosols, ocean acidification, and unsustainable freshwater use.



The 2018 report focused on assessing the impact of fibre use – from understanding for example how sheep farming and grazing affect the impact that wool garments have on biological diversity in local ecosystems, to its impact on climate change on the global scale for example.

This report is the first update and aims to expand the scope, not only to benchmark progress but also to continue to go into more granular detail based on improved access to data and insights from Houdini's suppliers and customers across the globe.

The initial goal in the first assessment was to base it on figures from Houdini's suppliers. This was more complex than had been anticipated and deemed not possible within the scope of the project. Instead the assessment was based on data from available life-cycle assessments (LCAs). The complexities involved in acquiring supplier-specific data remain.

This report's quantitative assessment is also primarily based on LCAs, but great emphasis is placed on qualitative approaches looking into various sustainability efforts made by Houdini, and their effects on both environmental and social dimensions. As part of the quantitative analysis using LCAs we have examined the possibility of using general LCA data as grounds for assessment. When we began working on the report The Higg Materials Sustainability Index (Higg MSI), from the Sustainable Apparel Coalition (SAC), was one of the more comprehensive platforms for such data beyond fibre production, including processes in fabric production. However, as we will discuss below, it still has a number of flaws and drawbacks – and, as a consequence, it was deemed not useful for the planetary boundaries assessment of this report.

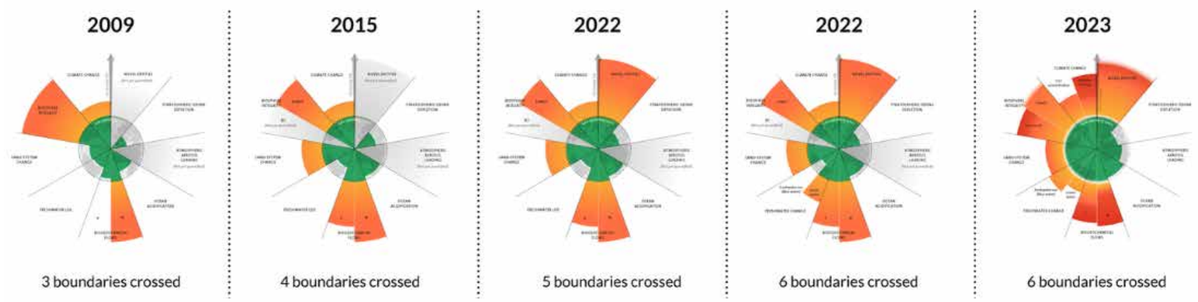
The first part of this report recapitulates the concept of planetary boundaries and looks into what has happened with it in science, business, and the outdoor sector in particular, over the past six years. This is followed by an analysis of the actions taken by Houdini since the previous planetary boundaries assessment, including changes in fibre use, new fabrics and garments, other sustainability efforts, a social responsibility update, and a look at the work to influence beyond the own value chain through promotion of a regenerative lifestyle. Finally, we discuss our results and come to a number of key conclusions and recommendations for the way forward.

2. The science of the planetary boundaries

WHAT STARTED IN 2009 when an international team of researchers published the first planetary boundaries framework in the journal Nature (Rockström and others, 2009) was a wave of reactions in the scientific community and beyond. The 2009 study has since been widely cited, picked up by other scholars, and used to inform policy and practice around the world. According to the first assessment, three boundaries had been crossed already in 2009: climate change, rate of biodiversity loss, and changes to the global nitrogen cycle. The framework was updated six years later (Steffen and others, 2015), refining the analysis and showing that human activities had resulted in the crossing of four of the boundaries: climate change, biodiversity loss, shifts in nutrient cycles (nitrogen and phosphorus), and land use.

In January 2022, an international team of researchers assessed the impact of the cocktail of synthetic chemicals and other "novel entities" flooding the environment (Persson and others, 2022). The 14 scientists concluded that humanity has also exceeded a fifth planetary boundary related to environmental pollutants including plastics. There has been a 50-fold increase in the production of chemicals since 1950. This is projected to triple again by 2050. Plastic production alone increased 79% between 2000 and 2015, the researchers report.

A reassessment of the planetary boundary for freshwater was published in April 2022 shows that a sixth boundary has now been transgressed (Wang-Erlandsson, 2022). This conclusion is due to the inclusion of "green water" – the water available to plants as rain and soil moisture – into the boundary assessment for the first time. Previously, the water boundary had been considered to be within the safe zone. However, the original freshwater planetary boundary only focused on extraction of water in rivers, lakes, and groundwater – known as "blue water". One example of the role of "green water" is the Amazon rainforest which depends on soil moisture for its survival. Now there is evidence that parts of the Amazon are drying out and losing soil moisture as a result of climate change and deforestation. These changes are potentially pushing the Amazon closer to a tipping point where large parts could switch from rainforest to savannah-like states.



In 2023, a full update of all the planetary boundaries was published, (Richardson and others, 2023). For the first time ever all nine planetary boundaries were assessed, and the researchers confirmed that six of nine have been crossed. While transgressing a boundary is not equivalent to drastic changes happening overnight, together they mark a critical threshold for increasing risks to people and the ecosystems we are part of. The ban of ozone depleting chlorofluorocarbons (CFCs) in the 1980s has meant that the ozone layer is slowly recovering, however, all of the other boundaries are currently moving in the wrong direction. If Earth was a human body, the planetary boundaries could be seen as the blood pressure. Over 140/90 does not equate to a certain heart attack, but it does raise the risk and, therefore, we work to reduce blood pressure. Likewise, being on the wrong side of a planetary boundary raises the risk of accelerating and abrupt change with severe consequences.

The reasons that more boundaries are crossed as the research is updated are both that human pressures on the boundaries are increasing and that there is improved evidence of the state of the boundaries. For example, the novel entities boundary was most likely transgressed already by the time of the first publication in 2009, but there was not enough data and scientific consensus to draw that conclusion at the time. Similarly, a revised way of defining the planetary boundary for fresh water in the latest update (2023) implies that it could be considered transgressed already by the time of the previous planetary boundary assessments.The freshwater boundary now addresses both "green" water (invisible water, held in soil and plants in farms, forests etc.) and "blue" water (visible water in rivers, lakes etc), and both boundaries were considered transgressed in the 2023 update.

Other new things in the 2023 update include that the team has for the first time quantified the boundary of atmospheric aerosol loading (air particle pollution). It is not transgressed at the global level yet, but rising pressures are evident in large regions where emissions of air particles impact monsoon systems. As another first, a new approach for assessing "biosphere integrity" was introduced. It involves measuring how much of the biomass produced by photosynthesis is being appropriated by humans globally, or is no longer happening, relative to pre-industrial levels. This boundary was transgressed already during the late 19th century, when global agriculture and forestry saw their first major expansions, according to the researchers. The update also added another sub-boundary for climate change: change in radiative forcing (a measure of how much energy is entering Earth's atmosphere from the sun, compared to how much is leaving).

In addition to the above mentioned major scientific updates, the planetary boundaries framework has been discussed, assessed and applied in a large number of other scientific studies. A review by Downing and others (2019), conducted ten years after the first study, concluded that almost 4000 research papers had cited the planetary boundaries framework at that time. Papers were separated into three main groups: (1) "commentaries" where researchers discussed the boundaries in relation to their own work; (2) advancements of the planetary boundaries concept; (3) explorations of how to apply the boundaries at national or regional scales, or in relation to social dimensions.

A main finding of the review was that the "planetary boundaries" framing has had a tendency to focus discussion on maximum allowable impacts on the planet rather than identifying what social transformations that can pave the way for a development that secures a good life for all within the safe operating space of planetary boundaries (but see O'Neill and others, 2018). This report's aim, and Houdini's own ambitions, are focused on the latter: to minimise the negative effects on climate and ecosystems while contributing to the urgently needed sustainable transformation.

3. The social aspects of the planetary boundaries

AFTER THE PLANETARY BOUNDARIES concept was introduced in 2009, Kate Raworth, then at Oxfam, led an initiative to complement the planetary boundaries framework with 'social boundaries' to create the 'Doughnut model'. It adds the aspects of living well to the notion of remaining within the planetary boundaries (see figure 1, below) (Raworth, 2012).

The Doughnut emphasises that universal human rights is an equally important aspect of sustainability. Through the addition of social boundaries (social equity, gender equality, political voice, access to clean water and food etc), a circular doughnut-shaped 'safe and just space for humanity' was created. The planetary boundaries delimit the 'ecological ceiling' within which humanity's collective activity must remain, and the social boundaries provide a 'social floor' above which a decent living and fairness for all are secured.

Sustainable development is about aiming for the "sweet spot" between those boundaries.

According to Raworth, "we cannot get into the Doughnut without tackling the distribution of global resource use in both consumption and production. Put simply, if we want to get into the doughnut, then we've got to tackle inequality" (Raworth, 2017). University of Leeds has subsequently used the Doughnut to compare the social and environmental performance of nations, and to foster a public discussion of what a "good life for all" could look like within planetary boundaries (O'Neill and others, 2018).

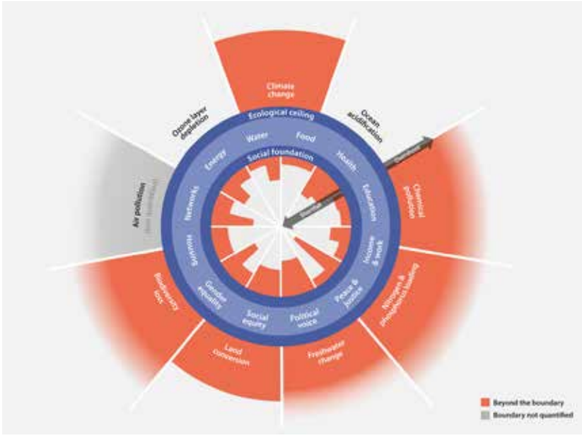


Figure 1: The Doughnut model – a good life for all within boundaries. Based on Raworth (2012 and 2017). The figure was updated in 2022 to reflect research on the water boundary (Wang-Erlandsson and others, 2022) and chemical pollution (Persson and others, 2022).

The social boundaries have been analysed for the textile and clothing industry and the most significant social risks were found to be related to wage, child labour, and safe working conditions (Zamani and others 2016).

Not surprisingly, the doughnut has a number of links to the sustainable development goals (SDGs) of Agenda 2030. Actually, each one of the doughnut's dimensions gets a mention in one or several of the 17 goals, or their 169 targets. But the social foundation is more fully and explicitly addressed than the environmental ceiling.

As a third layer in what it would take to reach a truly sustainable development, the initiators of the Inner Development Goals project (Houdini is one of the partner organisations) have identified a number of abilities, qualities or skills we need to foster among individuals, groups and organisations to fulfil the visions of Agenda 2030 and sustainability at large. Currently, the IDG framework represents five categories: Being – Relationship to Self; Thinking – Cognitive Skills; Relating – Caring for Others and the World; Collaborating – Social Skills; and Acting – Driving change. These are then further divided into a total of 23 skills and qualities.

Another complementing framework is The Good Life Goals. It represents an effort to help a global audience to recognize the vital role of individual action in achieving the SDGs. As such it lays out 85 ways anyone can contribute towards the SDG agenda, all identified through a multi-stakeholder collaboration between UN Environment, UNESCO, Stockholm Environment Institute, Futerra, and the governments of Sweden and Japan. One example is how SDG 12 about sustainable consumption and production patterns translates into Good Life Goal actions like: "Reuse, repair, recycle, share and borrow"; "collect friends and experiences, not just things"; and "demand that businesses respect people and planet".

4. Linking planetary boundaries to business

AN INCREASING NUMBER of companies have started to realise that, to become more sustainable, they need to take the whole value chain into account. A first step is often to focus on greenhouse gas emissions generated from own business operations and purchased or acquired electricity, steam, heat, and cooling, referred to as Scope 1 and 2 of the value chain by the Greenhouse Gas Protocol, a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Many companies have, however, realised that most emissions are found upstream and downstream (referred to as Scope 3) (see figure 5 in the next section). Mapping Scope 3 emissions is a good start and broadening the perspective has also paved the way for including other planetary boundary processes than climate impacts in the various scopes.

Recently, the first corporate science-based targets for nature were launched, helping companies think beyond climate and set targets for freshwater, land, and partly biodiversity, across value chains (Science Based Targets Network, 2023). Some companies have also started to incorporate social boundaries in their analyses and efforts, as conceptualised in the Doughnut model by Raworth (2012). Considering intertwined social and ecological issues is indeed a necessity to enable sustainable transformations of business. Doing this, however, implies increased complexity, revealing how the company operations are intertwined with more actors, greater geographical distances, multiple legal jurisdictions, and a myriad of other social, spiritual, and cultural values (Olsson and others, 2020).

This type of broadened perspective is also required in the new EU Corporate Sustainability Reporting Directive (CSRD), which modernises and strengthens the rules concerning the social and environmental information that large companies based in the EU have to report. Actually, according to the CSRD's European Sustainability Reporting Standards (ESRS) these companies will have to report impact on climate, pollution, water and marine resources, biodiversity and ecosystems, as well as resource use and circular economy. In essence, this means that an increasing number of companies will have to deal with their impacts on more or less all planetary boundary processes. Moreover, the ESRS implies that more companies in the EU will have to report on their effects on

several of the social boundaries described in the Doughnut model, e.g., effects on workers in the value chain, consumers and affected communities.

As concluded by Cranston and Steffen (2019), it is clear that linking the planetary boundaries to business is both an opportunity and a responsibility that can help companies set science-based targets and make meaningful decisions to help restore a well-functioning planet. However, as mentioned above, translating and applying the planetary boundaries at a corporate level implies that companies will need to overcome several practical challenges. One key issue is whether 'downscaling' or 'upscaling' from the planetary boundaries is the best way to enhance a company's sustainability strategy and decision-making. Cranston and Steffen (2019) make it clear that reducing the PBs to local or regional scales ('downscaling') is difficult to do in a scientifically robust way. Instead they encourage companies to ask "What if everyone in our sector behaved like us?". Using this kind of 'upscaling' approach seems to be particularly good in highlighting the need for regenerative activities instead of eco-efficiency that a 'downscaling' approach seems to drive. In other words, 'upscaling' would encourage companies to focus on doing "more good" rather than incremental changes or doing "less bad" (by focusing on 'downscaling').

Many companies indirectly recognize their impacts on several of the planetary and social boundaries through acknowledging the global goals in their corporate reporting and identifying the SDGs they consider most relevant to their business. However, reporting has to a large extent been unbalanced with most companies discussing their positive impacts but not the negative.

Companies are paying most attention to climate, decent work and economic growth and health while biodiversity on land, ocean health and hunger received the least attention (KPMG, 2018). This means that many of the planetary and social boundaries still remain underreported and unrecognised in the corporate world. Moving away from such a sectoral approach where social, economic, and ecological development are seen as separate parts is critical for achieving the sustainable development goals. It calls for a transition toward a new logic where the economy should serve society so that it evolves within the safe boundaries of the planet's climate and ecosystems (see figure 2 below).

Figure 2: The SDG 'Wedding cake' shows the 17 Sustainable Development Goals divided in a way that illustrates that the goals associated with economies and societies depend on the planet's biosphere (represented by Goals 6 on freshwater, 13 on climate, 14 on oceans, and 15 on biodiversity). (Illustration: Azote Images for Stockholm Resilience Centre)

Examples of efforts to analyse business impact on several planetary and social boundaries include the Swedish supermarket chain Coop's Sustainability Declarations (but see Perrigo and others, 2020); the French luxury brand Kering's Environmental Profit & Loss (EP&L) tool; the Environmental Product Declarations developed by workwear supplier Fristad and the research institute RISE; the Higg Materials Sustainability Index; and the ZQRX regenerative index developed by Houdini's supplier of wool (see more later in the report).

Actually, as reviewed by Metabolic, already in 2017 over 60 "One Planet Approaches" (methodologies, tools, programs, and action plans) existed, which relate human impacts to critical planetary limits. The bulk of these OPAs are still at a research or theoretical level, and very few have been applied in a real-world setting, particularly in the context of translating global or regional biophysical boundaries down to company or sector levels.

5. The apparel industry's impact on the boundaries

BOTH THE PLANET'S CLIMATE and ecosystems are affected in many different ways by how we produce, transport, wash, dye and dry, as well as recycle and dispose of our clothes. In one way or another, the clothes we wear are connected to each of the nine planetary boundaries (e.g. Zamani, 2016; Roos and others, 2017). In fact, the fashion and textile industry is now so large that it is becoming an important factor shaping the state of the whole planet (Cornell and others, 2021; figure 3).

Fig 3: The fashion and textiles industry in numbers, showing how resource use, production, consumption as well as social and environmental impacts have all accelerated in recent decades (Source: Cornell and others, 2021).

According to the Preferred Fiber & Materials Market Report (2021) the industry's impact will continue to grow. The report presents fibre production from 1975 until today, with projections for 2025 and 2030. The curve points steadily upwards with an 11% increase (from 98 to 109 million tonnes) from 2015 to 2020, and a projected further increase of 34% from 2020 to 2030 (fig 4).

Fig 4: Fibre production in million tonnes, from 1975 with projections for 2025 and 2030 (Source: Preferred Fiber & Materials Market Report, 2021)

Some impacts on the planetary boundary processes are generated from own business operations and electricity consumption (Scope 1 and 2 of the value chain), but these tend to be small compared to impacts from "upstream" and "downstream" activities, like production of fibre and fabric as well as use and later disposal of the actual garments (Scope 3)(see figure 5).

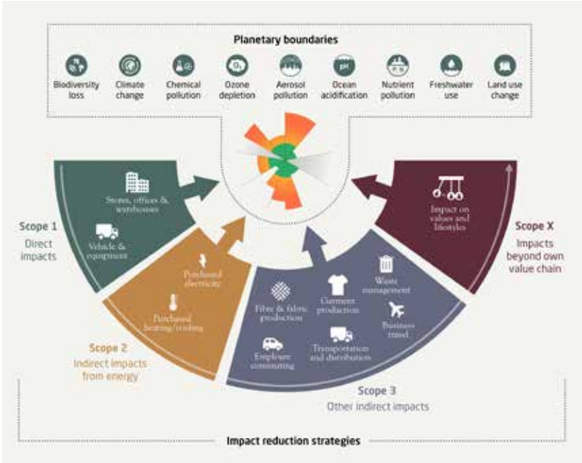


Fig 5: Impacts on the planetary boundaries come from scope 1, 2, 3 and 5.

To illustrate this, here are some examples. Polyester is a synthetic fibre – a type of plastic - and it is the most used fibre today, in tonnes. Vast amounts of fossil resources, crude oil, are extracted to produce polyester fibre along with other synthetic materials such as polyamide and acrylic. The resulting carbon dioxide emissions do not only affect the climate change boundary but also lead to increasing ocean acidification and potentially increased concentrations of aerosols in the atmosphere. Carbon dioxide is also emitted in the production of chemical fertilisers (which also contribute to the nutrient pollution/ biogeochemical planetary boundary) used in conventional natural fibre cultivation. For example cotton, a natural plant seed fibre from several species of plants of the genus Gossypium, the second most used fibre in the textiles industry, and one of the most pesticide (novel entities boundary) and water (freshwater boundary) demanding crops grown. Since cotton farming is often very intensive and based on genetically modified cotton grown in large monocultures, it also affects the biodiversity boundary and land use change boundary. The same is true for many other fibres grown for manufacturing clothes. The use of fertilisers can also lead to increased emissions of laughing gas (nitrous oxide), which has become the most important ozone-depleting gas after chlorofluorocarbons (CFCs) were phased out. Other parts of the value chain, such as transportation, spinning, weaving, dyeing and laundry, are also known to cause major emissions of greenhouse gases, nutrients, ozone depleting substances, hazardous chemicals, and microplastics.

In addition to all this, and specifically linked to outdoor clothing, some textiles are treated with chemicals for example to prevent odour or give garments water and dirt repellent properties. As garments are worn and washed these chemical treatments release from the fabric and wash out into the environment.

6. The clothing industry's effects on the nine planetary boundaries are further elaborated below:

6.1 Climate change

In 2022, the United Nations Intergovernmental Panel on Climate Change (IPCC) concluded that human-induced climate change has already caused dangerous and widespread disruption in nature and affected the lives of billions of people around the world (IPCC, 2022). This is unequivocally caused by human activities (IPCC, 2021), predominantly through the emission of greenhouse gases like carbon dioxide and methane, from land use change and the burning of fossil fuels in for example industries, agriculture, homes and the transport sector. A 2021 report from the World Economic Forum identified fashion, and its supply chains, as the planet's third largest polluter (after food and construction), releasing 5% of the world's greenhouse gas emissions, but according to other estimates it might be up to 10 %. Emissions happen in many different places along the long and increasingly complex supply chains of production, raw material, textile manufacture, clothing construction, shipping, retail, use, recycling, and disposal of the garments, but most of the greenhouse gas emissions come from the fossil fuels used to produce energy. Fast fashion and the enormous increase in the consumption of clothes cause an increasing impact on climate (and impacts on the other planetary boundaries). Research has concluded that it is not enough simply to "green" consumption by buying more sustainably produced clothes. It might even be essential to reduce overall consumption by up to 75 % (Fletcher and Tham, 2019), something that Houdini strives to contribute to by e.g. increasing the use of each produced garment. Houdini is also a part of The Exponential Roadmap Initiative, which brings together innovative, transformative and disruptive companies and organisations committed to halving greenhouse gas emissions before 2030.

6.2 Novel Entities

Novel entities include chemical pollution, but also radioactive waste, genetically modified organisms, and particles such as micro plastics. Globally, the production of plastics has increased 79% between 2000 and 2015 (Geyer and others, 2017) and chemicals 50 times since 1950 (Persson and others, 2022). The three largest plastic waste producing sectors are 40% from packaging, 12% from consumer goods and 11% from clothing and textiles. In 2020, the world's plastics weighed twice as much as all the planet's marine and terrestrial animals (see fig 6 below; Elhacham and others, 2020).

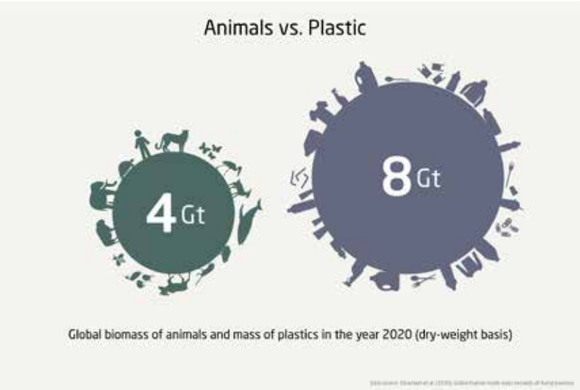


Fig 6: In 2020, the world's plastics weighed twice as much as all the planet's marine and terrestrial animals. Illustration: Azote Images, data source Elhacham and others, 2020.

The production of clothes involves the use and emission of a whole range of novel entities. For example, several allergenic and carcinogenic dyes that are banned in the EU are still used in many parts of Asia. Several potentially toxic substances are also used in the cultivation and spinning of fibres and in the weaving or knitting of fabrics. Different kinds of anti-mold agents are often added to protect fabrics during transport (Roos, 2016). Fabrics are also treated with chemical substances to produce desirable properties such as flame retardation, odour prevention and water and dirt resistance (e.g., PFAS, see Case5). In addition, tiny plastic particles are often released when washing synthetic fabrics (e.g. acrylic and polyester), which is contributing to the growing global plastic waste problem in the marine environment (WWF, 2016; Persson and others, 2022; see Case 6 MonoAir). Washing of synthetic materials is estimated to release 0,5 million tonnes of microfibres into the ocean every year, and a total of 35% of microplastics released into the environment (European parliament, 2017).

6.3 Stratospheric ozone depletion

International agreements, such as the Montreal Protocol and the associated Kigali Amendment, have been very successful in reducing emissions of chlorofluorocarbons (CFCs) and other substances that deplete the ozone layer (which protects life on Earth from harmful ultraviolet radiation). However, certain ozone depleting compounds are still emitted today and threaten to undermine international efforts to protect the ozone layer (Solomon and others, 2021). In the textile and clothing industry, ozone depleting nitrous oxide (N2O) can be released when fertilisers used in the production of natural fibres are broken down by soil bacteria. Transport of fibre, fabrics and garments is another source since ozone depleting nitrous oxides are emitted during combustion of fuels. Since the phasing out of CFCs, nitrous oxide has become the most ozone-depleting substance emitted by humans (Ravishankara and others, 2009). Another potential ozone depleting activity relating to the textiles industry is when clothes are dry cleaned, since dry-cleaning agents might still contain CFCs.

6.4 Stratospheric aerosol loading

Every stage of the textile value chain that requires energy input, including transports, can to some degree emit aerosols. The main sources of man-made aerosols are combustion of fossil fuels (such as gasoline, oil, and coal), wood, and charcoal. Aerosols are small particles in the air that can affect both the climate and human health. Some particles warm the Earth's atmosphere, while others tend to cool it (IPCC, 2021). Exposure to tiny aerosol particles has also been reported to cause 4.2 million premature deaths a year due to stroke, heart disease, lung cancer and chronic respiratory diseases (WHO, 2022). Import of fibre, fabrics and garments from countries where electricity is still produced from coal or diesel is particularly problematic. Ultimately, this often means that air pollution and other environmental impacts have moved far beyond the consuming country's borders. For instance, roughly half of the global textile and clothing production takes place in China, where energy is often produced from coal causing severe human health and environmental problems.

6.5 Ocean acidification

As mentioned above, production of textiles tends to lead to large emissions of carbon dioxide. This chemical compound is not only the most important heat-trapping (greenhouse) gas, it is also absorbed by the ocean where it dissolves into carbonic acid, making the oceans increasingly acidic (IPCC, 2019). Increasingly acidic conditions can have detrimental effects on marine species and cause disturbances in marine ecosystems, and all the vital ecosystem services that the ocean provides to humans. The more acidic the oceans become, the harder it will be for corals and other organisms to build their skeletons or shells from lime. If carbon dioxide emissions continue at the same pace as now the oceans will become so warm and acidic that coral reefs will disappear almost entirely within this century according to some scientists' forecasts (Hoegh-Guldberg and others 2015; IPCC, 2018).

6.6 Biochemical flows (nutrient pollution)

Nutrient pollution (eutrophication) is one of the major threats to oceans and lakes around the world, causing e.g. algal blooms and dead (oxygen-deprived) zones (e.g. Carpenter, 2005). The textiles industry's impact on this boundary is mainly in the runoff of nitrogen and phosphorus compounds from fertilisers used to grow different kinds of fibre crops. However, the washing of clothes can also be problematic, as laundry detergents sometimes contain phosphates. Most of the international discussion on eutrophication has circled around food production and consumption, but impacts associated with non-food commodities can be significant. Hamilton and others (2018), for example, found that clothing, goods for shelter, services and other manufactured products account for 35% of global marine eutrophication and 38% of the global freshwater eutrophication footprints. Transportation of textiles is another source of nitrogen as nitrogen oxides and ammonia are produced when fossil fuels are burned.

6.7 Freshwater use

The fashion industry is one of the most water-intensive industries in the world, using 79 trillion litres of water per year (Niinimäki and others, 2019). This is problematic since already in 2018 3.6 billion people had inadequate access to water at least one month per year. By 2050, this is expected to rise to more than five billion (WMO, 2021). The water used in households constitutes only a small share compared to water for irrigation in agriculture. It takes around 7,500 litres of water to make a pair of cotton jeans, equivalent to the amount of water the average person drinks over a period of seven years. Typically about 10,000 litres are required to grow one kilogram of cotton (Cherrett and others, 2005). The effects of such extensive water use and irrigation is particularly severe when fibres are grown in areas where water scarcity is an issue, for example around the Aral Sea in the 1960s when the region expanded its cotton cultivation and the lake decreased in size by 90% over a few decades. Other fibres also require water, of course, but cotton is the thirstiest (Defra 2010), which is one of the reasons Houdini does not use cotton. According to Roos and others (2016) an effective intervention to reduce water consumption is to replace cotton with forest-based or recycled regenerated cellulose fibres.

6.8 Land-system change

Large-scale cultivation of textile fibres is one major factor behind land use change. The impact is most severe when fibres such as cotton are grown in large monocultures that require chemical pesticides, fertilisers and irrigation, creating a land system very different from what was there before. Due to this and other kinds of conversion of land for human use Steffen and others (2015) concluded that humanity has moved out of the safe operating space for land use change. This means that we have reached, or even crossed, a point where further deforestation and expansion of agricultural land and urban areas could seriously threaten biodiversity, climate and water resources at the global level. Fibres not grown in monocultures, e.g. wool, can also require large areas of land, but grazing sheep can in fact contribute to biodiversity conservation and restoration of grasslands if well managed (e.g. Kviseth, 2011), which is the aim for the regenerative wool that Houdini is developing (see below, and case 4). Land use effects are comparatively low for synthetic fibres and relate mainly to fossil fuel extraction and transportation. Crop-based biosynthetics could require large land areas. Biosynthetics from forestry by-products could reduce pressure on this planetary priority (Cornell and others, 2021).

6.9 Biosphere integrity (biodiversity loss)

Biological diversity, or biodiversity, is a term used to describe the enormous variety of life on earth: within species, among species, and of ecosystems. “Biosphere integrity” can be described as the ability of ecosystems to continue to function and provide goods and services to human society, and the risk of these benefits being threatened tends to increase due to biodiversity loss. While much has been written about the textile industry’s impact on the climate, less well known and well covered is the industry’s huge biodiversity footprint. Around one million of the planet’s eight million species are now threatened with extinction, many within decades (IPBES, 2019), and only 4 % of the total biomass of all mammals on Earth is composed of wild animals (see figure 7). According to some estimates, the extinction rate is up to 1,000 times faster than the natural baseline levels (Pimm and others, 2014). The production and consumption of clothes is one of the culprits, in particular when fibres such as cotton are grown in large monocultures. Biodiversity conservation and textile production can, however, be combined.

One example is the collaboration between Houdini, Reda Group and the collective ZQRX (see case 4 below) to produce regenerative merino wool in New Zealand. Other environmental impacts caused by the clothing industry, during production, distribution and consumption, can have indirect effects on biodiversity, relating for example to climate change and emitted pollutants to land, air or water. Shipping of clothes can also lead to the spread of invasive species in ballast water that may cause ecosystem and infrastructure damage, economic losses and human health risks. Even though biodiversity is fast becoming a focus area for companies in the clothing sector, only 8 % of fashion and textile companies have an explicit biodiversity strategy in place (Textile Exchange, 2021).

Houdini have also joined the Half-Earth project, a call to protect half the Earth’s land and sea in order to manage sufficient habitat to reverse the species extinction crisis and ensure the long-term health and resilience of our planet.

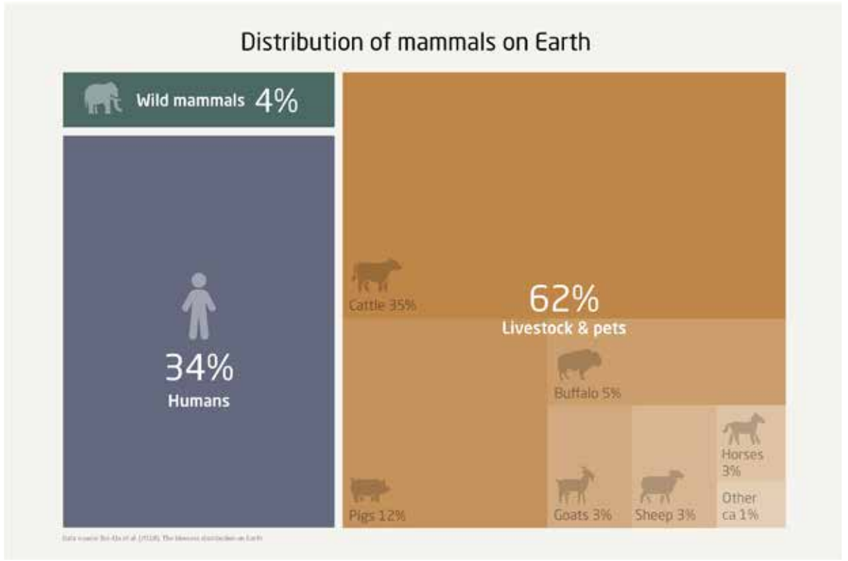


Fig 7: Distribution of mammals on Earth: only 4% are wild animals, 34% are humans, and 62% are livestock and pets. Illustration: Azote

7. Houdini's sustainability trailmap

EVER SINCE THE START in the early nineties, Houdini has made it clear that they see no contradiction between sustainability and good business. As such, Houdini's design and product philosophy has become increasingly centred around circularity, long lived products, a smaller and smarter wardrobe, resource efficiency and easy repairs. As mentioned above, in 2018, they also became the first company to make a planetary boundary assessment. The overall purpose and vision today is to have a positive impact on people and the planet, by "inspiring and enabling customers and others to reconnect to nature and lead a healthier and happier lifestyle". This is ambitious and the company has since 2016 worked according to a trailmap with some "big, hairy and audacious goals".

According to this trailmap, by 2022:

- All products should have been made from recycled and recyclable or renewable and naturally biodegradable fibres.
- The work to integrate regenerative materials such as waste from land, ocean or air turned into resources should have been initiated.
- Full traceability and transparency in Houdini's value chains should have been implemented.
- Houdini Hangouts should guide, educate and inspire people worldwide to reconnect to nature through "friluftsliv", a conscious outdoor lifestyle
- Houdini Open Source should have been initiated as a platform for sharing knowledge on sustainable methodologies, technologies and solutions worldwide.
- Collaborations to explore and develop attractive and regenerative lifestyle solutions should have been initiated.

In hindsight, most goals set for 2022 were achieved – but not all. For example, 100% of all the fabrics Houdini used in 2022 were recycled, recyclable, renewable, biodegradable or Bluesign certified. The work to develop regenerative fibre alternatives has been ongoing and will result in a number of new products to be launched over the coming seasons. In terms of traceability and transparency, Houdini have come a long way, often all the way to the farm, fibre and chemical supplier, but the communication of this to their to users is still limited. Moreover, the Houdini Hangouts have started again after the pandemic; the open source platform has been piloted through openly sharing all the "secrets" behind The Mono Air Houdi fleece jacket designed to minimise plastic waste; and a regenerative lifestyle initiative has been launched.

And according to the trailmap, by 2030:

- Natural resources taken from the earth's crust have been replaced by recycled or renewables.
- All waste streams, including micro plastic pollution, have been transformed into resource flows.
- At least 20% of textile fibres used are regenerative alternatively waste from land, ocean or air turned into resources.
- Material resources for trimmings, dying, process chemicals and treatments have shifted to circular and/or sustainable renewables.
- 100% of energy used throughout value chains for production and recycling have been shifted to sustainable renewables.
- The Houdini ecosystem in its entirety is net neutral on its way to become regenerative.
- Houdini's Open Source strategy results in accelerated scaling of sustainable methodologies, technologies and solutions worldwide.
- Collaborations to enable attractive and regenerative lifestyle solutions have developed into an integral part of Houdini's business model and scaled.
- Reconnect to nature has grown into a strong and uniting movement, with various collaborations cultivating and strengthening the movement further and towards a positive tipping point in society.

By 2066:
Decoupled from today's unsustainable societal system, Houdini together with like minded, have cultivated a new societal system where nature, society, economy and technology work in harmony and life is flourishing.

The 2066-goal was inspired by the Stetind Declaration, a Deep Ecology declaration written by fellow mountaineers Nils Faarlund, Arne Naess och Sigmund Kvaloey Setreng in 1966. Houdini was its first signatory and formulated a 50-year trailmap to turn it into reality.

The Stetind Declaration

WE HAVE GRADUALLY COME TO REALIZE:
We have gradually come to realize: That our way of life has fateful consequences for nature and human- kind, and thus for all life on Earth. The challenges we face as individuals and as a community are not merely of an economical and technological nature. They concern our basic values and our fundamental conception of what it means to be human.

WE ACKNOWLEDGE THAT:
Nature and humankind constitute a whole and share a common destiny. Nature is the home of culture. Life is like a woven fabric of relations. To live is to be dependent. The value of nature and human dignity are intrinsically linked. What we do to nature, we do to ourselves. All life is vulnerable and therefore under threat. Concern for nature implies a concern for greater justice: Our way of life affects in particular the poorest among us, indigenous peoples, and future generations.

WE WILL:
Work to promote a renewed understanding of the relationship between nature and humankind. Strive to base our choices, both as individuals and as a community, on this understanding. Discover the joy of living in harmony with nature: There is no path to harmony with nature. Harmony with nature is the path. Humankind possesses great capacity both to create and to destroy. At this crucial point in time we will take responsibility and commit ourselves to thinking and living in a way that promotes life.

8. Assessing Houdini's impact on the boundaries

8.1 Methodological approach

Below we look into the progress of Houdini's trailmap since 2018 by again using the planetary boundaries framework to deep dive into a number of examples of activities and efforts made by Houdini since 2018. To best account for all nine boundaries and as much of Houdini's value chain as possible, within the scope of this project, we have based our analysis on several data sources and approaches/methodologies.

We started by looking into fibre use and how it has changed at Houdini in comparison with data from the 2018 planetary boundaries assessment. This was followed by an analysis of Houdini's fibres, based on a literature review and LCA studies. We also examined the potential of using platforms such as the Higg Materials Sustainability Index (Higg MSI), from the Sustainable Apparel Coalition (SAC) for assessing impact according to the planetary boundaries framework and beyond fibre production including processes in fabric production.

To address the social aspects added to the planetary boundaries in the Doughnut model (Raworth 2012, 2017) we have included an analysis of Houdini's suppliers, their code of conduct and other social sustainability work.

We have also looked at a range of Houdini's other activities and initiatives from a planetary boundaries perspective, including new designs, circularity efforts, various certifications, chemical management, collaborations, campaigns and knowledge sharing.

8.2 Results and analysis

In this section of the report we have chosen to start with the big picture, focusing on Houdini's circular business model, including designing for and encouraging longer use of the products, as well as promoting more sustainable lifestyles. We start here as these holistic approaches are key from a planetary boundaries perspective as they reduce the need for using virgin raw materials and producing new garments. We then go into more detailed analyses of the production of individual fibres, fabrics and products to manage the effect on planetary and social boundaries. You might say we move from the big picture to the zoomed in pixel-level. In doing so we move from changes and interventions that have effects on a system level – potentially pushing a transformation towards sustainability – to tweaks within the system, with effects that are to no degree unimportant but that may not have the same potential to set in motion a cascade of change.

We want to emphasise the need for system change that we believe is necessary and that we see the seeds of in many of Houdini's initiatives and standards. However we don't want to lose track of the importance of improvements made along the way, improvements and choices that can be part of spurring niche innovations that drive a larger transformation.

8.3 Promoting a regenerative lifestyle

Based on our analyses it has become obvious that it is not enough to look at the production of individual garments to assess the effect on planetary boundaries. The perspective needs to be broadened to also include the amount of products Houdini encourage their customers to consume, as well as the values and lifestyles that are enabled and promoted. The latter has been labelled Scope X (Townsend, 2020), and is a way to account for emissions (and other environmental impacts) from a company's influence on their customers as well as on other actors in society. This complements the other three scopes of emissions: scopes one and two: all the direct emissions from fleets, factories and purchased energy; and scope three: all the indirect emissions, e.g. from supply chains and how people use products. Why should a company act beyond their direct or even indirect impacts and work for system change? Because attempting to become a sustainable business is pointless in an unsustainable system.

In the quest to influence the apparel sector at scales that matter, Houdini and others can adopt different strategies to scale their influence to large-scale or systemic impact. These have been labelled 'scaling out', 'scaling up', and 'scaling deep' in the scientific literature (Moore and others, 2015). Scaling up is about achieving greater numbers through adoption of something more sustainable (e.g. more people buying sustainable outdoor apparel). Scaling out involves institutional and policy changes through adoption of a new more sustainable innovation or strategy (e.g. other companies mimicking Houdini's new fleece material engineered to prevent microplastic pollution; or their use of new smart chemical free membranes could inspire legislation that prohibits the use of hazardous chemicals with dirt and water-repellent properties). Last but not least, scaling deep is defined as something that impacts culture and alters behaviours and norms.

Houdini's Scope X, and how it can be scaled, has been analysed in detail in a white paper by Pamlin and Hedström (2020). The report's perspective can be summarised in the formula: I = P * V + L. It describes a company's impact on the planet (I) as a function of (P) how the products are produced (where most companies focus their efforts); (V) the volume of the goods sold; and (L) the lifestyle that a company enables and supports. Working with this formula as a guiding principle, Houdini have made it clear that their sustainability efforts cannot be confined to only make individual products less destructive, or even regenerative. They also want to promote longer use, reuse, repair, and rental of their products, as well as having an influence on people's lives in different ways, from outdoor experiences, via mobility and nutrition to activism. Spending more time in nature, for example, is known to boost people's health (Remme and others, 2021) and increase their understanding of both natural resources and environmental degradation (Giusti and others, 2014).

On a personal level, the V in the formula above is related to (a) Number of goods (Wardrobe size) of the customers, and (b) Time the garments are used. As seen in the graph below (fig. 8), over the last ten years the global average number of days a garment is worn

before it is thrown away has fallen from approximately 200 to close to 120, but in parts of the world this number is as low as 7-10 times for some garments (Ellen MacArthur Foundation, 2017).

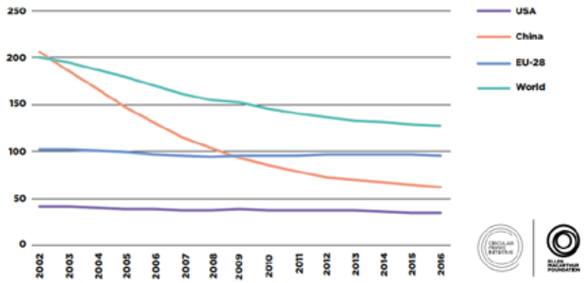


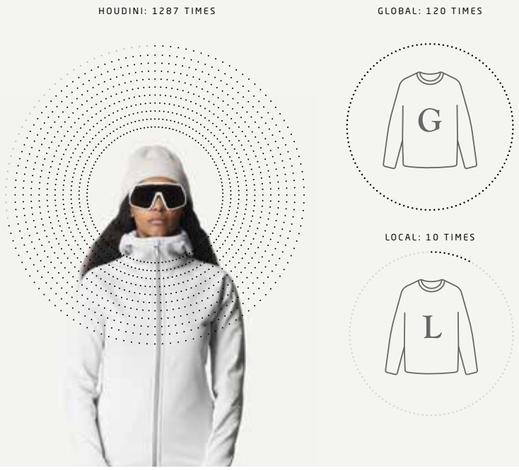
Fig 8: The average number of times a new garment is worn, including ruse, within the regions USA, China, EU-28, and the world. Source: Eller MacArthur Foundation, 2017

In contrast, Houdini's products are often used many times more than the average garment and for a longer time (see case 1). The average number of times someone wears their Power Houdi was 1287 times, for over 10 years. This means the Houdi is owned and worn about 10-100 times longer than the average garment. Needless to say, this enables reduced consumption and production of new garments (unless the customer has a big wardrobe) and thus substantial savings in natural resources and pressures on all planetary boundaries. According to Sandin and others (2019), for example, using a garment twice as many times compared to average, will decrease the climate impact by 49% in a Swedish context. This means that the greenhouse gas emissions from a t-shirt, which is used on average 30 times in Sweden, can be cut in half if it would instead be used 60 times. Actually, in Sandin and others (2019) twice as many uses per garment life-cycle was found to eliminate almost 50% of impact regardless of impact category, which included climate change, energy use, toxicity, water depletion and impacts of land use. Houdini's responses to such findings also include the #LiveLargeWithLess-challenge, which was launched on social media in May 2022 to challenge their community of users to only use 10 garments during the entire summer.

CASE 1:

Power houdi: A "wearable multitool" that is built to last

One of the main conclusions of Houdini's 2018 planetary boundaries assessment was that designing for a long life is key to lessen the impact on climate as well as all the other planetary boundaries. One year later, in 2019, a survey was conducted with over 400 Power Houdi users, showing that the average number of times someone wears their Houdi is 1287 times, for over 10 years. In contrast, the average piece of clothing is worn around 120 times globally, and in some parts of the western world the average garment is worn only 7-10 times (The Ellen MacArthur Foundation, 2017; Morgan and Birtwistle, 2009). This means a Houdi is used 10-100 times more than the average garment, gathering that many more stories. In 2021 Houdini launched a global marketing campaign, "The Storyteller", to tell the stories of their products' long use through emotional and humorous snippets. This was followed in 2022 by Houdini's #LiveLargeWithLess-challenge, encouraging their community to only use 10 garments for the whole summer. In these ways the company wants to influence their customers and contribute to a shift from producing and selling new products to the maintenance, use and care of existing garments – such a shift from extractive and linear production systems to circular approaches is key to stay within planetary boundaries (Cornell and others, 2021). In the case of the Power Houdi, this is of extra importance since it is made of three different materials (57% polyester, 33% polyamide, 10% elastane) that can not yet be separated to be recycled. Pending recycling technologies Houdini stores all worn-outs from its take-back system since 2007.



ALL SECTORS

Using a garments 100 times longer does, however, not mean the pressures on all the planetary boundaries are 100 times less since the use of the garment implies effects on several boundaries when it is being used, e.g. climate impacts from energy required by the washing machine, nutrient pollution from detergents, and microfiber leakage due to the mechanical and chemical stress caused by the washing process. Worth noting is that Sandin and others (2019) came to the conclusion that in Sweden, the use-phase laundry is of little direct importance in terms of climate impact (most of the electricity supply comes from low carbon dioxide-emitting hydro and nuclear power). On the other hand, they also stressed that more frequent laundering will shorten polymeric chains and thereby increase leakage of microfibers and potentially reduce the number of uses. To counteract this Houdini is working in many ways to minimise the environmental impacts of the use phase, e.g. encouraging customers to wash less often, offering washing bags to help protect the garments, collaborating with Electrolux on future apparel care solutions, providing and developing shedding-free alternatives (see case 6 on the Mono Air Houdi) and shifting to natural materials without synthetics.

CASE 2:

Connected products: visualising the journeys users and their products

Houdini was one of the first brands to release a garment with a “connected” zipper and unique product-ID. The One Parka is equipped with YKK’s Touchlink™ NFC zipper pull, and by touching their phone to it, customers can for example connect with customer service and access use- and care-guides.

The same piece of technology connects each garment end-to-end by the EON Product Cloud. Creating digital profiles for each garment enables them to be connected, managed and stewarded and lowers the threshold for models for resale, rental, subscription and recycling. As each garment is logged in the cloud, its journey can be tracked from point of first sale, through different users and activities, to end-of-life and recycling. Parallel, Houdini has introduced garments with QR-based product IDs.

Houdini have pledged to be fully circular by 2030, and have committed to digitising all garments as a part of reaching circularity.

Connecting garments to the cloud can help producing brands to take full responsibility for a product. The possibilities stretch beyond material responsibility and circularity: by engaging customers through their connected garments Houdini will work to turn consumers into users and caretakers, or even into investors and activists for a sustainable future.

Houdini developed an app where customers could log their activities – if a mountain was climbed, a jacket was lent to a friend or used on a bike commute – to generate a lifeline for each garment. The ambition was a long and vibrant lifeline for each garment, illustrating a loved item that had been on many adventures and logged many hours of use.

Extending use and life of a product has the potential to decrease impact on all planetary boundaries. And encouraging an active lifestyle with social and experiential values held high can benefit the users in many ways. The cost/benefit analysis between these goals and the material as well as environmental cost of the technology should make for an interesting follow-up on the net-effect.

ALL SECTORS

8.4 Houdini's circular approaches: beyond design and production

8.4.1 Products that are circular by design

Since, 2020 all of the fabrics used in Houdini's designs are recycled, recyclable, renewable, biodegradable or Bluesign certified. The goal is to create a fully circular system, where long-lasting products can be used, repaired and reused and then finally be recycled to become new resources again. Below (fig 9) show

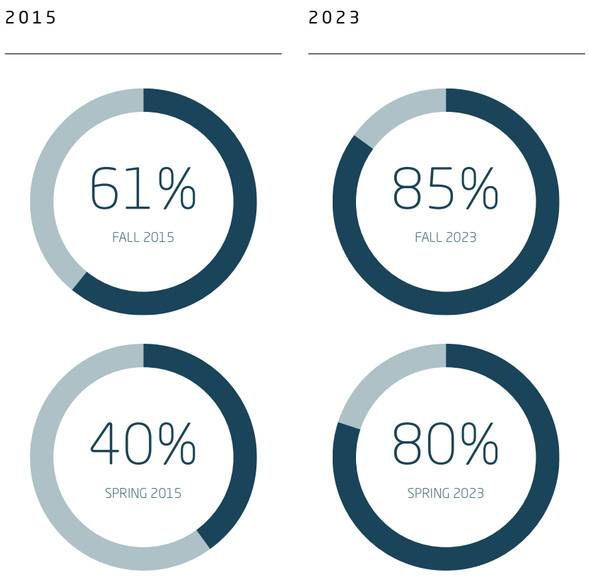


Fig 9: 85% of Houdini's fall and winter collection 2023 was made from fully circular materials. 80% of Houdini´s spring summer collection was made from fully circular material.

Houdini's advancement in share of circular styles comparing 2015, the basis for the first Planetary Boundaries Assessment to 2023, the basis for this assessment. We want to emphasise the need for system change that we believe is necessary and that we see the seeds of in many of Houdini's initiatives and standards. However we don't want to lose track of the importance of improvements made along the way, improvements and choices that can be part of spurring niche innovations that drive a larger transformation.

Recycling of synthetic materials can be done through mechanical and chemical methods. Natural fibres are biodegradable and can be composted as well as recycled and used for new products, often in eg padding.

In addition to being circular in design and materials, Houdini aim to create a circular ecosystem to make sure that the materials that are borrowed from nature are used as much as possible. This approach includes Rental, Reuse and Repair in addition to traditional sales to allow many different needs to be fulfilled. Rather than a business model conducted in silos they focus on an entire offering towards the users, with a diversity of business models that can complement each other. The same user can have a need for all of the models, for example to buy a product and care for it for many years and repair it when needed, but also buy and sell other garments second hand and finally rent a garment for a special occasion. It's the system that creates a more sustainable offer, not the models themselves.

For an overview of Houdini's circular system see figure 10 below, known as the butterfly diagram (from Ellen MacArthur Foundation, 2019), illustrating the technical cycle (synthetic fibres) and the biological cycle (natural fibres). In the technical cycle, products and materials are kept in circulation through processes such as care, share, reuse, repair, remanufacture and recycling. In the biological cycle, fibres can also be kept in circulation by similar means, and eventually the nutrients from biodegradable materials can be recycled to regenerate natural ecosystems and grow new fibres.

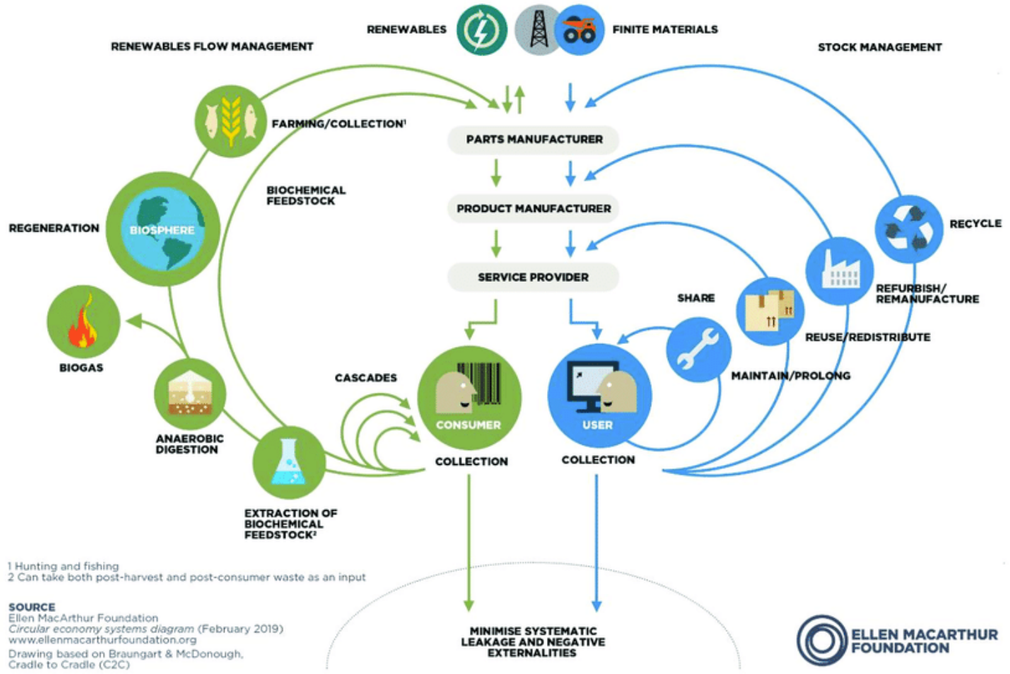


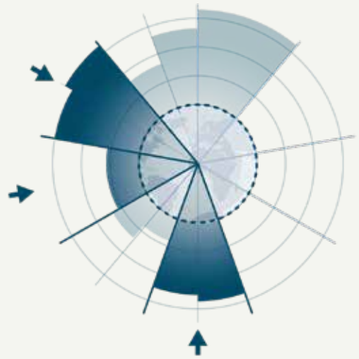
Fig 10: For an overview of circular principles for product and raw material flows, see the "butterfly infographics" from the Ellen MacArthur Foundation, 2019, illustrating the technical cycle of synthetic fibers and the biological cycle of natural fibers.

CASE 3:

Merino wool products that are pure enough to be composted

IN 2016, HOUDINI LAUNCHED an experiment by putting clothes from their merino wool line in a compost and later served a fine dining menu using vegetables grown from the soil. This was done to show that it is possible to create performance apparel that is pure enough to be composted. While conventional merino is often blended with synthetics or treated with hazardous chemicals that do not belong in nature, Houdini has managed to produce a natural material in merino wool, Tencell (a wood-based fibre) and a mix of the two. But their customers have to make sure to first cut away details like zippers, cords etc. In a good compost, a shredded wool garment usually decomposes in 6-12 months. Before it is time for the compost, Houdini encourages their customers to return worn out garments to them. The textiles can often be repurposed before they are ready to go back to the soil. Wool can also be recycled, but with degrading quality with each recycling, similar to paper. Recycling organic matter in this way can imply reduced or even positive effects on planetary boundaries processes like nutrient cycles, biodiversity and land use.

BIODIVERSITY LOSS
LAND USE CHANGE
NUTRIENT POLLUTION



8.4.2 Rental (and subscription)
Rental was first launched in 2012. To encourage customers to think differently about garments that may not be frequently used, Houdini started offering an in-store rental service of both base and shell layers. Since 2021 Houdini also offers an online rental service in collaboration with Continued Fashion. In addition to rentals, which are short term leasing for a week or a weekend, Houdini have also tried out a subscription model – full access to a Houdini wardrobe paid by a monthly fee. Subscription ran during 6 months as a local pilot project in Stockholm during the winter of 2018/19.

A 2020 life cycle impact assessment (Böcklin and others 2020) looked at environmental impact of rentals from an example product (shell layer jacket) per economic profit for Houdini. This is key as the long-term sustainability of garment rental business models depends on that they generate profit, in the rental model compared to "normal" sales".

The authors performed an LCA of the example product, based on the OpenLCA database and the ILCD (The International Reference Life Cycle Data System) impact categories (which partly correspond to several planetary boundary processes; see Fig 11). Based on this they could conclude that the rental model resulted in reduced impact per amount of generated profit in all environmental impact categories except ozone layer depletion (Böcklin and others 2020 and Fig 11). They also saw that the rental model resulted in a shift of where impacts take place from production to the transportation of customers in the use phase.

The strength of the rental model compared to the sales model is that it reduces the volume of garments needed, both to satisfy customer demand and to secure revenue to Houdini. The cost of a week's rental is about one seventh of that of purchasing a shell layer jacket. For many people, one week per year satisfies the need for a shell layer for skiing, for example. Reducing the cost for the individual user in this way is an opportunity for more people to afford versatile and functional outdoor clothing without having to compromise with materials and sustainability standards.

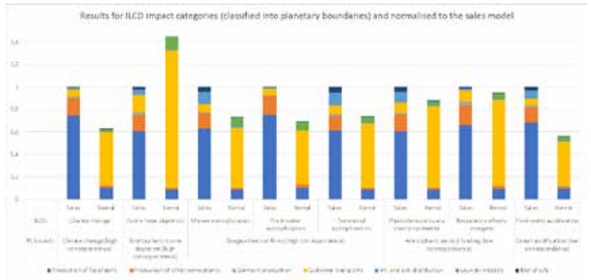


Fig 11: Impact assessment results per functional unit for eight different ILCD impact categories, normalised to the sales business model and classified into five planetary boundaries (with a note on the level of correspondence between the ILCDimpact category and the planetary boundary). Source: Böcklin and others 2020.

8.4.3 Reuse
Since 2011 Houdini has had second hand item racks in their stores as an effort to extend the lifetime of their products. The second hand sales ("Houdini Reuse") are now also available online and include garments re-sold by Houdini in "crisp" condition from customers (who are rewarded with gift card for handing in clothes they do not use); claims that have been repaired; and garments that have been a part of the rental service. The price is often around half that of a brand new garment of the same kind.

Though not operated by Houdini, a mark of their long-lasting designs is that they were one of the top-15 most sold brands on Swedish online "circular market" Tradera in 2022 (Tradera, 2022).

8.4.4 Repair
Houdini offers a repair service in order to make sure products last long. Customers who want to repair a Houdini garment can use a digital repair service that Houdini runs together with Repamera, an EIT Climate-KIC start-up based in the city of Malmö, Sweden. Anyone using the services gets a prepaid shipping bag, which can be used to send in garments and get them back repaired within 10 days. The repair service is also available through all Houdini stores and in collaboration with repair services worldwide.

Both reuse and repair can, in the same manner as rentals, help reduce the number of garments used, and hence also lessen the negative impact of producing new fibres, fabrics and garments.

8.4.5 Houdini Circle
In September 2023 Houdini opened the doors to a new type of concept store in Stockholm, called "Houdini circle". In the store customers can buy, rent or subscribe to everything from new to second-hand garments, including well-worn repaired garments and exclusive remake pieces. This is the first Houdini Circle store and it will run as a pilot as Houdini, with support from the Boston Consulting Group, evaluate the business model and come up with a way to price the garments fairly in all customer options. The concept offers a new solution that challenges the dominant sustainability stories from fashion – all typically centred on production. Through their Circle store Houdini hope to pioneer a new way of setting up sustainable business models for retail.

Both reuse and repair can, in the same manner as rentals, help reduce the number of garments used, and hence also lessen the negative impact of producing new fibres, fabrics and garments.

8.5 Houdini's fibre use

Houdini's material use is an important part of the company's impact on planetary boundaries. Actually, about 70% of all global greenhouse gas emissions are related to material handling and use (Circular Gap report 2022). So unless companies reduce the volumes and change how materials are produced and used, it will be difficult to meaningfully cut emissions. Houdini have chosen to use either synthetic fibres that are recycled, recyclable and/or bluesign certified, or natural fibres that are biodegradable. They never blend natural and synthetic fibres, as such blended materials are difficult to fully recycle with retained quality, and are not fully biodegradable (e.g., Sandin and Peters, 2018; see case 3.

In total Houdini's fabric consumption amounted to 98 654 kg for the two seasons F23 and S23. This is an increase of 70%, from 57 821 kg in F14 and S15.

Today Houdini use three natural fibres: lambswool, Merino wool and Tencel™ Lyocell, and five synthetic fibres: polyester, polyamide, elastane, polyurethane and kevlar/aramid (see figure 12 below). As seen in figure 12 below, virgin and recycled polyester (from PET bottles) constitute 26,5% and 40% respectively of the total fibre use (in kg), polyamide is the second largest fibre with 15.5%, followed by Tencel™ Lyocell with 7,5%. Elastane constitutes 4% of the total use. These numbers are used below when choosing which fibres to focus on in the analysis.

The share of Houdini's collection consisting of pure natural fibres, fully biodegradable without synthetic treatments, has increased from 6,2 % in 2014-15 to 11 % in 2023 (see fig 12). Tencel™ Lyocell increased from 0 % to 7,3 % while wool decreased from 4,9 % to 3,8 %. During the same period mechanically recycled polyester increased from 12,9 to 38,3 % while chemically recycled polyester decreased from 20,6 to 2 %. At the same time, the virgin fossil materials polyester, polyamide and elastane all decreased significantly. Still, virgin polyester and other virgin synthetic materials together comprise 48 % of the fibres used by Houdini, leaving plenty of room for improvement in the coming years – as described in their strategy for 2030, e.g., "striving to replace all natural resources taken from the earth's crust with recycled or renewables".

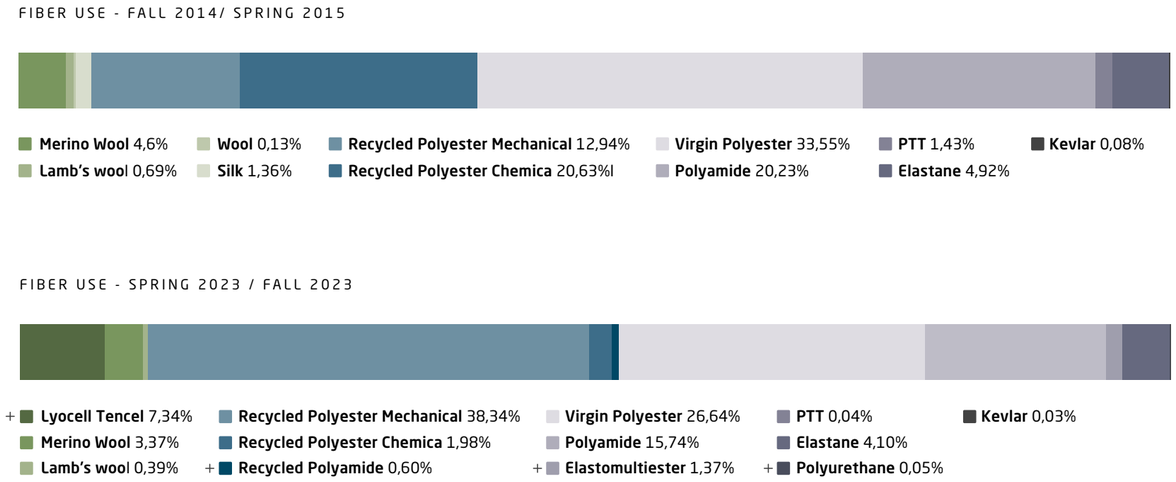


Figure 12: Houdini´s advancement in kg of yearly material consumtion in kg fiber from the last report until 2023, the basis for this assessment.

Fibre	*Consumption (kg)*	*Consumption (%)*
Lyocell Tencel	7165,86	7,34%
Merino Wool	3290,08	3,37%
Lamb's Wool	383,69	0,39%
Recycled Polyester Mechanical	37432,51	38,34%
Recycled Polyester Chemical	1934,73	1,98%
Recycled Polyamide	581,10	0,60%
Virgin Polyester	26008,22	26,64%
Polyamide	15363,82	15,74%
Elastomultiester	1341,33	1,37%
PTT	42,32	0,04%
Elastane	4002,85	4,10%
Polyurethane	47,91	0,05%
Kevlar	29,95	0,03%

Table 1: Total consumption of fibres in kg and percent for Houdini during the period of Spring/Summer 23 and Fall/Winter 23.

8.6 Transitional fibres

The previous planetary boundaries analysis identified 27% of the 33% polyester to be "transitional", since a conversion process from virgin to recycled fibres was in place. Similarly, 15% out of the polyamide was identified as transitional. Unfortunately, converting transitional fibres has not progressed as planned since the last report – even though Houdini have worked hard to push the transformation. There are several reasons why movement has been slow: For example slow progress and availability of recycled synthetic fibres due to lack of incentives from policy makers. To some extent any company's ability to push for and enact change hinges on national and international trade and political conditions. Houdini and partners are pushing for change, but the system is slow to move.

Changing to materials consisting of recycled fibres, or a higher amount of recycled fibres, is not always compatible with a higher quality and durability – it can affect for example the life span of a garment or the amount of microfibers it sheds. The balancing act where changing from one solution to another does not create new problems or affect another of the planet's boundaries in a negative direction is therefore sometimes challenging. Moreover, Houdini is dependent on and acting in an existing market with legal and global issues that sometimes makes it hard to act according to their own sustainability goals. Houdini and their close partners are doing all to control their actions to push the industry although it is crucial that policy incentives are also changing to create big ripples and change.

8.6.1 Houdini's material substitution

Houdini's circular principles and drive to enhance product performance and sustainability requires and inspires continuous improvements and innovation. This includes development of new fabrics and technologies or improvements of existing qualities, fibre composition, treatments, and production methods. Since the last Planetary Boundaries Assessment in 2018 79% of Houdini's fabrics have been substituted as they have been deemed to not fulfil Houdini's principles of sustainable and circular principles. This substitution happens continuously as Houdini raise their standards and as new technologies are developed. The share of styles that are recycled, recyclable, renewable, biodegradable or Bluesign certified, has increased since the last report in 2018 (based on 2014/2015 data). This progress is key in Houdini's vision of a waste free world, where worn out products can be used for something new. 85% of Houdini's Fall & Winter collection 2023 is circular and the goal is to continue increasing this share.

Figure 13: The share of Houdini's styles that are made from recycled, recyclable, renewable, biodegradable or Bluesign certified from fall 2014 (F14) to Fall 2023 (F23).

8.7 Assessing fibre impact using LCA data and qualitative analysis

In order to follow up the previous planetary boundary assessment we have updated the LCA and qualitative analysis of impact from fibre choice. A total of nine fibres were included this time compared to six in the 2018 assessment. As a reference fibre, we also include conventional cotton in the analysis, as it is one of the most used materials in the global fashion industry and has been excluded by Houdini because of its environmental impacts.

The LCA data serves as proxies for the different fibres' potential impacts on some of the planetary boundary processes, but does not make it possible to analyse the local level environmental effects of the actual fibres used in Houdini's own value chains.

The analysis is limited to the production of fibres. Where sufficient and specific data has been found, the fibres are compared quantitatively. For three of the planetary boundaries (novel entities, land-system change and biosphere integrity), we have conducted a qualitative comparison based on a range of information sources. Two boundaries, atmospheric aerosol loading and ocean acidification, have been excluded from the analysis as data was insufficient and indicators not adequately known. Atmospheric loading is also not a quantified planetary boundary.
and change.

Fibre	*Climate Change*	*Biosphere integrity*	*Biogeochemical flows*	*Land-system change*	*Freshwater use*	*Stratospheric ozone depletion*	*Ocean acidification*	*Novel entities*	*Atmospheric aerosol loading*
Proxy	kg CO2 eq/kg fibre	Happy/ Neutral/ Sad (q)	kg phosphate eq/kg fibre	Happy/ Neutral/ Sad (q)	Litres water/ kg fibre	kg CFC11 eq/kg fibre	kg CO2/ kg fibre	Happy/ Neutral/ Sad (q)	N/A
Conventional cotton	0.94 (s)-1,9 (p)	☹	0.0038 (a)-0,022 (b)	😐	900 (s)-2130 (a)	6.0E-13 (s)-3.1E-7 (n)	N/A	☹	N/A
Organic cotton	0.98 (a)-1.1 (s)	😐	0.0028 (a, s)	😐	182 (a, s)*	1.6E-15 (s)-3.3E-12(s)	N/A	😐	N/A
Polyester	8.5 (d)	😐	0.0012 (b)	😐	130 (b)	7E-8 (b)	N/A	☹	N/A
Chemically recycled polyester	0.98 (f)-2.59 (o)	😐	0.0023 (o)	😐	N/A	N/A	N/A	😐	N/A
Mechanically recycled polyester	0.96 (o)-3.88 (k)	😐	0.0008 (o)	😐	N/A	N/A	N/A	😐	N/A
Wool	7-37 (c)	☺☹	0.012 (n)	☺☹	225(t)-721 (h,g)	5.1E-7 (n)	0.6-1.8 (g)	😐	N/A
ZQ wool	11 (c)	☺	N/A	☺	N/A	N/A	N/A	☺	N/A
Polyamide (6/66)	6.9(s)-7.91 (s)	😐	0.0015(s)-0.0046 (s)	😐	16-1200(s)	8.6E-14(s)-9E-8 (m) (N6)	N/A	😐	N/A
Lyocell	2.5 (b)	😐	0.0018 (b)	😐	263 (b)-265 (j)	1.1E-7 (b) 0.07-0.11 g (b)	N/A	😐	N/A
Hemp	0.36-0.86 (u)		N/A		N/A	N/A	N/A		N/A

Table 2: The table presents available LCA data points for the respective fibres and boundaries. It also presents a qualitative analysis for those boundaries where no or insufficient data is available, represented by happy/neutral/sad faces. For several fibres and boundaries no adequate data was found, and two boundaries (atmospheric aerosol loading and ocean acidification) were excluded from the analysis. Lack of data is presented in the table as N/A (not available).

The spans in impact category for each planetary boundary process speak to a number of challenges in comparing and contrasting different fibres and different LCA studies, for example: 1. There are big differences in impacts between producers; 2. There are big differences in methodologies between LCA studies; and 3. There are uncertainties in some instances in translating impact to match the proxy used. For climate change the proxy is CO2 equivalents and researchers have a clear understanding of the major contributors and how to translate them. However, for e.g., ozone depletion it is less clear which substances should be accounted for and how they translate in impact to the proxy CFC equivalents.

A qualitative assessment has resulted in three impact categories. Positive impact (happy face), neutral/not severely detrimental impact (neutral face), negative impact (sad face).

A note on magnitudes in each column - the proxies for each boundary are presented in metric units kg/kg or l/kg, however there are big differences in order of magnitudes between different impact categories. For instance the amount CFC11eq per kg fibre is very low - for polyamide it is a mere 0,09 milligrams per kg fibre - this is represented in the table as kilograms tens to the power of x, in this case x=-8, written as 9E-8 kg (0.00000009 kg).

For ZQ wool we have identified EPD's performed to measure impact across more categories than climate change. However the studies were done measuring impact per m2 of fabric and in a manner that made it too difficult to confidently and accurately calculate backwards for the purposes of this report, therefore there is only one data point for this fibre.

Cotton: According to LCA experts it is difficult to accurately infer impact on the water boundary from LCA data. What can be concluded is that cotton is a water demanding crop and conventional cotton is often grown in arid regions, putting pressure on what little water is available. A practice that jeopardises access to fresh water in areas of higher priority than fibre production (eg, drinking water, health, hygiene, food crop production, animal husbandry). Conventional methods for cotton production have many negative effects on biodiversity - as do all intensively farmed monocultures. It represents a land-use change that is overall on the negative side and as conventional cotton production tends to be pesticide heavy it also has a negative impact on the novel entities planetary boundary.

Polyester: Polyester is produced from fossil resources. Our overall assessment for polyester has become more strict since the 2018-report as the need to move away from fossil resources has become increasingly urgent and insufficient responses to this need can be seen globally. Virgin polyester's impact on novel entities is now assessed as negative as the production of new synthetic materials is increasingly difficult to justify. Recycling of polyester is assessed as neutral as it circulates synthetics that are already produced (it is, however, important to note that there are issues of microplastic and chemical leakage as well as energy consumption in the recycling process).

References:

a) Textile Exchange, 2014.

b) Shen L, Worrell E, Patel MK, 2010.

c) Wiedeman and others, 2015.

d) Ecoinvent, 2016.

f) Patagonia: Patagonia's Common Threads Garment Recycling Program: A Detailed Analysis.

g) Wiedemann, S.G and others, 2016

h) DEFRA, 2010.

i) Van der Velden, N. M., Patel, M. K., & Vogtländer, J. G. 2014.

j) Textile Exchange. 2016.

k) Newlife 2017

m) Roos and others 2015 + databas Ecoinvent 2.2

n) Ecoinvent, 2017. Ecoinvent 3.3 database. Characterised in GaBi 6, using ReCiPe 1.0 Midpoint (H).

o) Shen L, Worrell E, Patel MK, 2010.

p) Cotton Incorporated, 2012.

q) These are qualitative assessments made by the authors of this report and based on a literature review and interviews with key stakeholders (scientists and practitioners). Key references include: DEFRA, 2010 (biodiversity, land-use and novel entities); Textile exchange, 2014 (novel entities, land use); Van der Velden and others, 2014 (land use, novel entities); Wiedemann and others, 2016 (land use); Roos and others, 2015, 2016, 2017 (biodiversity, land use, novel entities).

s) GaBi Professional Database 2022 Edition results extracted from Gabi.

t) Wiedemann and others, 2020. Environmental impacts associated with the production, use, and end-of-life of a woollen garment. The International Journal of Life Cycle Assessment, 1486-1499.

u) de Beus, Barth, M., Carus, M., 2019. Carbon footprint and sustainability of different natural fibres for biocomposites and insulation material – study providing data for the automotive and insulation industry [revised edition 2019]. Available at:http://eiha.org/media/2019/03/19-03-13-Study-Natural-Fibre-Sustainability-Carbon-Footprint.pdf [Accessed August 2022]

8.8 Qualitative analysis

The assessments have been complemented with a science-based qualitative analysis where suitable quantifications are not available or were deemed to not adequately represent the actual effect on each planetary boundary process. The qualitative analysis is a combination of insights and data around land transformation, farming practices and chemical use.

Novel entities: The novel entity planetary boundary was assessed as being transgressed by Persson and others (2022). Though it is not quantifiable in a straightforward proxy, researchers have concluded that the combined effects of synthetic chemicals and plastics have pushed us beyond the safe limit of the boundary. And though no exact measurement can be found on the sum total of all toxic effects, the fibres used by Houdini have been assessed based on a qualitative estimate from the literature of how severe chemical pollution they contribute to. Conventional cotton (included for comparison but not used by Houdini) and virgin polyester have been deemed the worst out of the fibres in this qualitative assessment. Conventional cotton because of a typically high use of agrochemicals (fertilisers and pesticides). Virgin polyester as it is a fossil resource which post-extraction will contribute greatly to micro-plastic pollution for example.

Land system change: A suitable proxy for the planetary boundary for land system change in a fibre production context might seemingly be a measure of hectares/tonne fibre produced. However it is more complex than that. Wool provides an illustrative example: If sheep are kept on large enough pastures, in an extensive production fashion, their grazing and trampling can serve to restore degraded land and even contribute to increasing biodiversity and ecosystem services such as water purification. If, however, they are kept in narrow enclosures the impact on the land, long-term, is more likely to be negative. Impact then correlates inversely to the proxy hectares/tonne fibre. Similarly, for cotton or Tencel production, extensive production, in for example diverse agroforestry systems, could produce more benefits and be less harmful than intensive production. Impact depends to a large extent on the management of the production system.

Biosphere integrity: There is no single adequate LCA proxy for biodiversity impact. In recent years, however, several tools and methods for assessing biodiversity risk and impact have been developed. One example is a method for assessing biodiversity impact based on land-use intensity (Chaudhary and Brooks, 2018) that has been used by for example WWF in their "Vegoguide", a consumer guide for a plant based diet. The Science Based Targets Network (SBTN) has also developed a 5 step guide for corporations to assess their impact on nature (Science Based Targets Network, 2020). In alignment with the SBTN framework WWF has launched a "Biodiversity Stewardship Programme" to help companies understand biodiversity-related risks in and beyond their direct value chain and implement changes for improvement as well as an approach for identifying, assessing and addressing biodiversity risks and opportunities (Church and others, 2022). Another example is the Ecogain Biodiversity Index (EBI) which was recently used to analyse close to 400 of the largest companies in Europe (Karlberg and others, 2022), but it focuses mainly on how large companies report on biodiversity in their sustainability reports, not so much on their actual impact on biodiversity along their whole value chains. Ecogain and members of the Business@Biodiversity Sweden network have also developed CLImB (Changing Land Use Impact on Biodiversity), a practical tool for assessing nature in Sweden and the Nordics in a transparent and comparable way (CLImB, 2023). Actually, the Taskforce on Nature-related Financial Disclosures (TNFD, 2022) reports that there are over 3,000 metrics currently in use to measure nature-related impacts, but also that the lack of standardisation of these metrics limits measurement, management and reporting and poses challenges for providing comparability across and within sectors.

Since the first planetary boundary assessment was published in 2018 awareness of the importance of biodiversity has increased and there are now initiatives working actively to boost regenerative practices in wool production.

CASE 4:

Regenerative wool: textiles that grow biodiversity

WOOL IS ONE OF THE natural fibres that has increased its share of the total Houdini fibre use. It has a long history of textile use and many desirable qualities, however, wool is also an example of the complexities involved in assessing environmental impact. While wool is not made from fossil resources, producing it still results in greenhouse gas emissions – simply because sheep are ruminant animals and their digestive tracts produce methane. However, wool growers employing careful management of their grazing sheep can actually contribute to restoring degraded land – improving soil health, protecting and enhancing biodiversity, water ways, and increasing carbon sequestration in the soil and vegetation.

Houdini source wool strictly from suppliers that focus on sustainable production. Together with the ZQ farms of The New Zealand Merino Company (NZM), Houdini contribute to the development of a framework for regenerative management in wool production. Called ZQRX, it is a wool-sourcing programme for sheep farmed using regenerative principles, developed under the ZQ-umbrella by NZM. Through the ZQRX Index NZM measures 15 key performance indicators (KPIs) split into three categories: environment, animals, and people.

- Environment: biodiversity, waste, water, climate, land
- Animals: management, nutrition, physical environment, health, protection
- People: staff & contractors, health & wellness, diversity & inclusion, learning & development, community

The scores for the different ZQRX KPIs were developed using a change management framework called ADKAR (Awareness, Desire, Knowledge, Ability, Reinforcement; see Table 3 below). All growers that are already part of ZQ have proven that they are aware of, and mitigating, the challenges addressed by the 15 KPIs and, hence, they all start with a score of 2. Further evaluation is based on both an open dialogue with growers and scientific measurements which provide evidence towards the KPI score received. The programme has a philosophy of continuous improvement, so it is worth noting that the highest scores of 9 and 10 should be considered very aspirational and not expected to be reached in the first years of the programme.

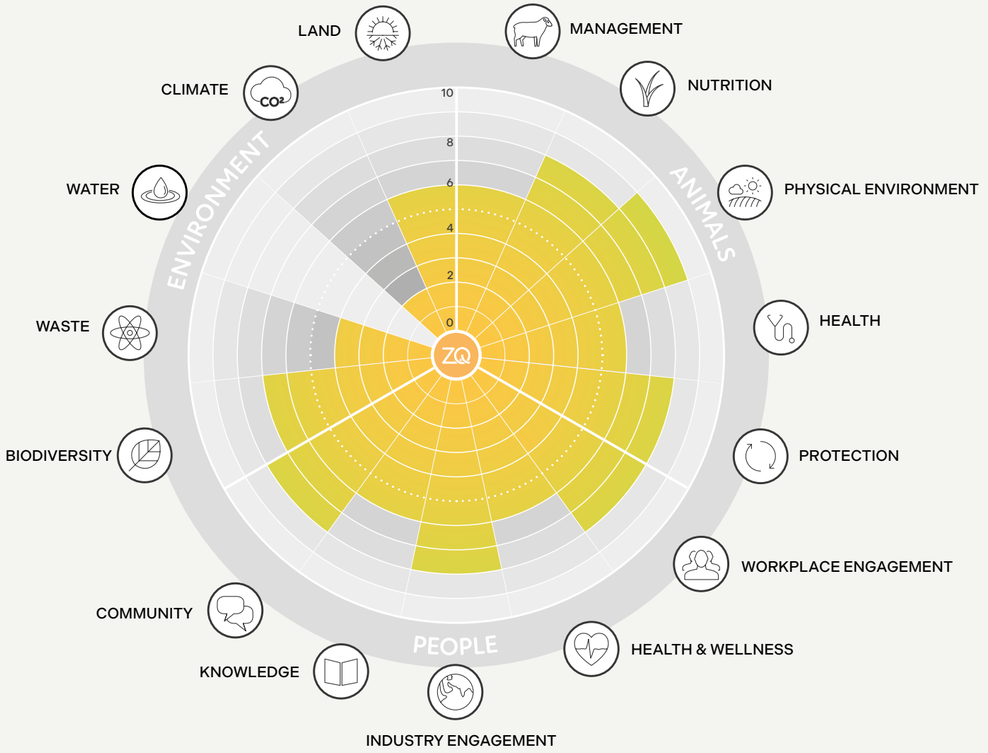


Table 3: Summary of the scoring system employed by the ZQRX Index.

Score	*Outcome*	*Explanation*
1/2	Awareness	Growers have an awareness of prevalent issues
3/4	Desire/Interest	Growers have an interest to learn more and desire to address prevalent issues
5/6	Understanding/Knowledge	Growers have measuring & monitoring systems in place to capture information around these issues
7/8	Action/Ability	Growers are taking decisions based on measurd data to improve and anddress these issues
9/10	Champion/Giving back	Growers are taking their measure data and sharing it widely to help others make and address change

Within ZQRX the goal is to address social impacts, animal welfare, and environmental issues connected to biodiversity, waste, water, climate, and land use. As a rule, regenerative production systems aim to increase ecosystem health and contribute positively, for example via restoration and carbon storage. This means that regenerative farming is one way to not only reduce pressure on the planetary boundaries but to try to strengthen and build back ecological health, capacity and resilience.

FRESHWATER USE
CLIMATE CHANGE
BIODIVERSITY LOSS
LAND USE CHANGE
CHEMICAL POLLUTION
NUTRIENT POLLUTION

8.9 Testing data platforms as a tool for evaluating material choice from a planetary boundaries perspective

One challenge with assessing impact on the planetary boundaries is data availability: on the one hand the difficulty of getting producer specific data, and on the other the lack of standardised and comparable metrics. One approach to solving this problem are platforms and databases that consolidate data and ensure comparability (in methods, indicators and proxys).

When we started working on this report the The Higg Material Sustainability Index (MSI) was one of the largest such platforms. For the purpose of this report we tested using data from the Higg MSI on Houdini's fibre mix to see how these data correlate with findings from previous LCA studies and how they align with the planetary boundaries framework. In relation to the planetary boundaries we found that, much like with data derived from LCAs directly, there are significant gaps in the Higg MSI data (which is not surprising or counter to any claims we have seen made by Higg or SAC). The normalisation process in the Higg MSI is also relatively opaque and produces results that are not directly reflected in LCA data we have found.

As tools for informing decision making and fibre choice as well as for communicating sustainability efforts or informing customer choice we also see a number of other issues with relying on data from these kinds of platforms. One key challenge is that the data only considers how materials are produced, not how long they last (how many times a garment is used), how they are taken care of, whether they're linked to plastic pollution, or what happens to them when consumers are done with them.

One possible advantage of platforms such as the Higg MSI, where data from different suppliers and producers is gathered and harmonised, is that it could be used to compare and visualise the impact of various fibres and methods along the many steps in the fabric production chain – and show alternatives with potential of lowering the impact. This does not cover the whole value chain (cradle-to-grave), but can help to make clear that different stages in the production chain contribute to different degrees to the total impact of a fabric, and that there are different methods with higher or lower impact. Previous studies of textiles' impact on the planet have found that fibre selection is not the only, or even the most important, aspect to consider for more sustainable material production (e.g., van der Velden, 2014, Sandin and others, 2019).

Switching methods for e.g. colouration can mean significantly lower impact on the five categories included in Higg MSI. Many potential methods that result in decreases are likely known to producers but visualising them could help to emphasise the difference and might nudge companies to move for change.

8.10 Chemical and plastic pollution

The planetary boundary of chemical pollution, microplastics and other so-called novel entities is one of the most urgent to address, both in general and for the apparel sector in particular. In order to deal with this problem, Houdini have for example developed alternative fabrics and taken efforts to eliminate leakage from existing synthetic materials (see e.g. case 6 about the Mono Air Houdi). They have also used inspiration from nature's own chemistry to make sure waterproof outerwear is never treated with PFAS (Per- and Polyfluorinated Alkyl Substances) or other harmful chemicals (see case 5 below).

Moreover, Houdini have their own "restricted substances list" (RSL) that suppliers of both materials and garments need to follow. This list exceeds the industry and regulatory standards as Houdini's have developed their own tougher restrictions with "zero tolerance" (towards substances that are listed as hazardous or that may cause damage to humans or nature) and "less is more" (no chemicals should be added that aren't really needed). The legal background for Houdini's RSL is various national and international regulations and restrictions, including UN global treaties on certain hazardous chemicals, such as Persistent Organic Pollutants (POPs), and EU/EEA chemicals regulations. The RSL lists major restricted substances and the risk level associated with each substance for different materials.

As an example of their work with hazardous chemicals and restricted substances Houdini's materials are completely free of per- and polyfluoroalkyl substances (PFAS) - one of the most widely used chemical types in shell-layers. PFAS gives the garment water- and dirt repellent properties, but is also a persistent pollutant. In the European Union, production and use of many PFAS has been illegal for most applications since 2006, but it has since been replaced with compounds with very similar chemical structures, whose potential environmental impacts are not fully known. Houdini, however, have been 100% PFAS free since 2018, meaning that all waterproof outerwear is made from a PFAS free membrane together with a biobased water repellency treatment inspired by nature (see case 5).

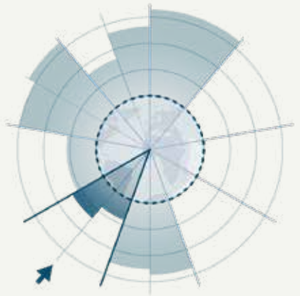
CASE 5:

Free from PFAS with inspiration from nature's own chemistry

One group of hazardous chemicals contributing to the novel entities planetary boundary is PFAS, a range of chemicals used for water- and dirt repellency. Houdini is one of the first brands in the outdoor industry to have phased out PFAS. These chemicals do not break down naturally, are cancerous and have shown negative effects on both reproductive and immune systems for humans and animals. Recently it was even suggested that PFAS should be considered a planetary boundary of its own and that it has already been exceeded (Cousins and others, 2022). Houdini started phasing out PFAS already in 2012, and since 2018 all waterproof outerwear is made from circular performance fabrics which are never treated with PFAS or other harmful chemicals. Together with the research institute RISE and others, Houdini has also been part of the innovation project POPFREE 2017-2022 aiming to promote PFAS-free alternatives and contribute to increased awareness in the textile industry. This has among other things resulted in a PFAS substitution guide for textile supply chains (RISE, 2022).

Today Houdini use a PFAS free membrane called Atmos together with a PFAS free water repellent treatment. They also work with biobased water repellency treatments, to use for reboothing, from OrganoTex®. The product is completely fluorocarbon-free (PFC free) and is instead based on natural fatty acids that make the fabric water-repellent. The technology is inspired by nature's own chemistry, similar to how a Lotus leaf repels water and dirt, i.e. a waxy layer of tiny pimples keep the water at a distance. This way of developing sustainable solutions with the inspiration from nature is called biomimicry. Staying dirt-free is an obvious advantage for the Lotus flowers (Nelumbo nucifera), an aquatic plant living in typically muddy habitats. And they do so without using detergent or expending energy. Lotus leaves just can't get wet or dirty because they have superhydrophobic surfaces. Water drops that fall onto them bead up and roll off. The leaves do not only stay dry, but the droplets also pick up small particles of dirt as they roll, making the lotus leaves' hydrophobic surface self-cleaning.

CHEMICAL POLLUTION



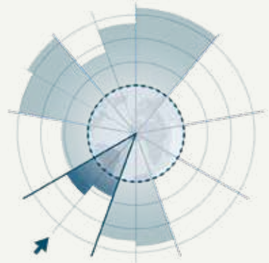
CASE 6:

MonoAir: collaborative Open-Source innovation

The Mono Air houdi was launched in late 2020 as the first garment made from a pioneering fleece material engineered specifically to prevent microplastic pollution from microfiber shedding. The material, Polartec® Power Air™ Lightweight, is the result of a collaboration between Houdini and Polartec® where three goals were set: Reducing microfiber shedding; improving performance; and eliminating waste by designing a circular garment. Polartec® Power Air™ Lightweight consists of two layers of knit fabric, encapsulating lofty polyester filaments in small pockets. The material is made with 73% recycled polyester and 27% virgin stretch polyester, making it fully recyclable. Tests have shown that the microfiber shedding from Polartec® Power Air™ Lightweight is only one fifth compared to other premium mid-layer fleece fabrics.

Sharing is caring, and Polartec® Power Air™ Lightweight is now part of Polartec's catalogue and can be ordered by anyone. And the full "recipe" for the Mono Air Houdi is available on Houdini's website. "Some innovations are too good to be kept secret" – the idea behind the collaboration with Polartec goes beyond wanting to create an attractive and sustainable garment or collection, it is about moving the sector and reducing the negative effects of microplastic pollution on a broader scale.

CHEMICAL POLLUTION



8.11 Assessment of social sustainability

Fabric and technologies sourcing at Houdini is based on a highly selective partnership strategy, with long-term relations with world leading fabrics and technologies supplier partners and manufacturers. Houdini have worked actively to contract only socially responsible suppliers from the start. They have a small number of suppliers compared to the rest of the apparel sector, where the typical business reports having between 1,000 and 2,000 suppliers on average, and between 20,000 and 50,000 if sub-suppliers are included (McKinsey, 2019). Having a limited number of suppliers enables Houdini to develop long-term relationships and close dialogue, as well as avoiding unapproved sub-contractors.

8.11.1 Sourcing strategy

Fabric and technologies sourcing at Houdini is based on a highly selective partnership strategy, with long-term relations with world leading fabrics and technologies supplier partners and manufacturers. Fabrics are sourced mainly from Japan, Italy and the US. This enables Houdini to provide high quality and best practice while also maintaining high environmental, social and ethical standards. Equally important, the partnership strategy results in improved trust and transparency, making analysis of current practices possible, improvement plans easier to implement and innovation projects comfortable to invest in. Houdini's value chain is global and their supplier partners are very few. Most of them produce their fabrics in countries where high social and environmental standards are regulated by law, and federal control functions are in place.

Manufacturing at Houdini mainly takes place at selected and specialised European partners in Estonia, Latvia, Lithuania, and Portugal. This manufacturing network is situated relatively close to Houdini's global distribution centre in Sweden (which could be considered "local" in a textile supply chain perspective), enabling a lean set-up with tight collaboration and an efficient way of working, meeting and shipping. In addition, EU social and environmental standards apply and legal requirements and government control functions are in place, meaning that sustainability efforts are at a high level even at baseline. Local manufacturing has multiple benefits, and Houdini see great potential in developing this local value chain further. Meanwhile, Houdini also have the ambition to export their high social standards and practices to manufacturers elsewhere in the world in order to push social and ethical boundaries further and on a global scale.

Along these lines, Houdini have recently expanded their collaboration and production with a partner in Vietnam. The partner has production facilities in Europe as well as in Vietnam where Houdini have now moved some of the production. The Vietnamese manufacturer is one of Houdini's well selected partners and they have collaborated on garment manufacturing for many years. This is one example of how Houdini work with their selective partner strategy to build trust and transparency, and have the ability to develop partnerships with control.

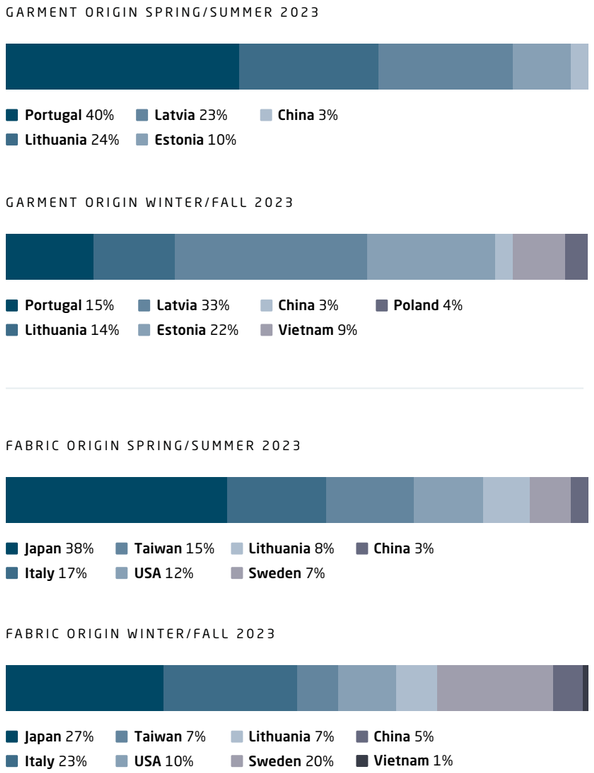


Figure 14: Sourcing at Houdini for the Spring/Summer 2023 and Fall/Winter 2023 on styles.

8.11.2 Traceability

Houdini strive towards a fully traceable and transparent value chain. They conventionally engage with suppliers from "tier" 1 all the way to tier 3 or 4 (tier 1 are direct suppliers, tier 2 are the suppliers' suppliers, tier 3 are the suppliers or subcontractors of tier 2 suppliers, and so on). Houdini believe it is a great benefit for a company to be transparent, as it enables them to continuously build trust. In fact, the way they see it, it is also an obligation as a company to be transparent: "A company owes it to itself, end-users, customers, colleagues in the business, as well as to the public, since in the end everybody is interdependent in the local as well as global and planetary perspective". See below examples of how Houdini work with transparency through the supply chain.

Figure (15) The Alto Half Zip value chain, exemplifying how Houdini nominates every component of a garment – from fiber and fabric, to zippers, sewing tread and labels.

8.11.3 Sourcing countries from a social risk perspective

One common way of assessing suppliers from a social perspective is to use the Amfori BSCI (Business Social Compliance Initiative) Country Risk Classification, which Houdini do in their risk assessments of different suppliers. The classification is based on the Worldwide Governance Indicators (WGI) from the World Bank. The indicators assess the level of risks related to governance in sourcing countries and consist of six dimensions:

1. Voice and Accountability
2. Political Stability and Absence of Violence/Terrorism
3. Government Effectiveness
4. Regulatory Quality
5. Rule of Law
6. Control of Corruption

Several of these dimensions correspond to social boundaries of the inner ring of the Doughnut model (see figure 1), e.g. the first dimension is similar to "Political voice" and dimension 2 and 5 to "Peace and justice" in the Doughnut.

The overall score across the six dimensions defines how a country is classified, as a "risk country" or "low risk country". Risk countries are countries with WGI average rating between 0 and 60, or with three or more individual dimensions rated below 60. Low-risk countries are countries with WGI average rating higher than 60 and no more than two individual dimensions rated below 60.

Below are two diagrams (fig 16 and 17) showing the countries Houdini sources materials from (percent of total weight of materials consumed 2023), both for garments and fabrics. In both diagrams "risk countries", according to the Amfori BSCI (2021), have been coloured red.

Among Houdini's suppliers, only 9.6 % of garments come from risk countries (China and Vietnam) and 7.3 % of fabrics (also China and Vietnam). This is of course a result of the above mentioned work with the Houdini Code of Conduct and the long-term efforts to actively contract only a small number of as socially responsible suppliers as possible.

Being based in a risk country does not automatically imply a certain supplier performs poorly in social responsibility, but the Amfori BSCI classification certainly can help companies define their priorities in terms of monitoring, capacity building and stakeholders' engagement.

Looking at the overall risk scores of all countries that Houdini buy garments and/or fabrics from, reveals that 93 % (14 out of 15) are low risk countries (WGI average rating higher than 60; see diagram below). In fact, 60 % of the sourcing countries have a score of 80 or more.

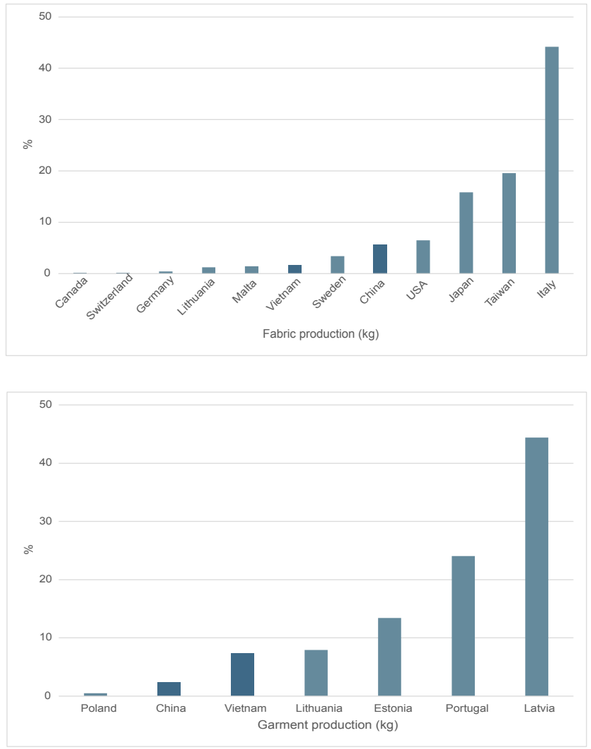


Figure 16 and 17: Approximately 10 % of Houdini's garments come from risk countries (China and Vietnam) and approximately 7 % of fabrics (also China and Vietnam). All other suppliers are based in low-risk countries.

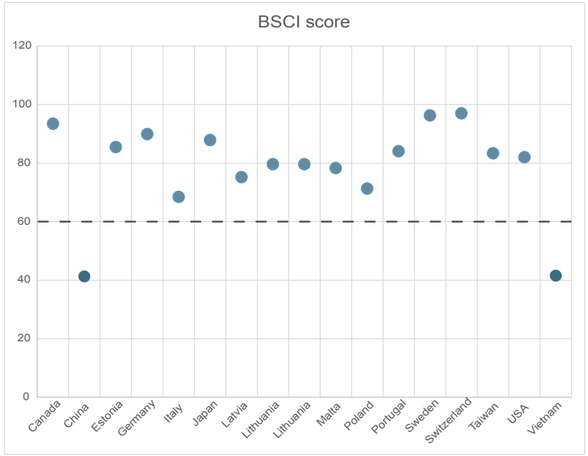


Figure 18: 15 out of 17 countries where Houdini have garment and fabric suppliers are low-risk countries, with BSCI scores above 60.

Since Houdini's fabrics and garments are mainly produced in low-risk countries like Japan, Latvia and Portugal, there are relatively high social standards among their suppliers. This implies that legal requirements and government control functions are in place, and that most minimum social requirements as defined by the Doughnut model are met even at baseline, but improvements can definitely be made. Interestingly, an online tool, based on data from the World Bank, UNICEF, ILOSTAT and University of Leeds, now makes it possible to visualise the doughnut for all countries, and compare their performance relative to the social and planetary boundaries.

See below two examples of the difference for China and Portugal according to the Doughnut model online tool.

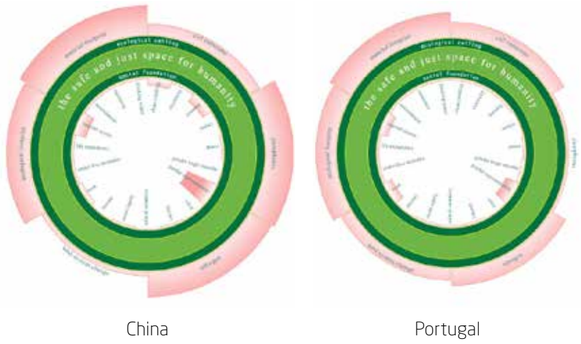


Figure 19: How China and Portugal respectively perform in relation to the social and planetary boundaries. Created by an online tool based on data from the World Bank, UNICEF, ILOSTAT and University of Leeds, visualising countries' performance according to the Doughnut model. Data is estimated and may have been gathered at different times in different countries. The visualisations are meant to serve as a quick reference to approximate where countries fall on the doughnut spectrum.

As mentioned above, Houdini have a relatively small number of suppliers, making it possible to visit all the garment and fabric suppliers several times a year. This partnership strategy is a good foundation for maintaining trust and transparency, making analysis of current practices along the value chain possible, and improvement plans easier to implement.

8.11.4 Selective partnership strategy

The Amfori BSCI score gives Houdini an overall picture of the state in the country, but it does not say anything about the actual partners that Houdini is sourcing from and producing with. A manufacturer or supplier in a risk country could have higher environmental and social standards than one in a low-risk country and the other way around. This is why a sourcing strategy is important. Houdini´s strategy is based on highly selective partnerships and long-term relations with fabric and technology suppliers and manufacturers. This qualitative strategy together with Houdini's Code of Conduct, Manufacturer's Framework and third party social and environmental audits, aim to ensure high standards regardless of country. Houdini's ambition is to export its holistic and high standards and practices to manufacturers everywhere and to push boundaries further and at the global scale.

Spectre is one of Houdini's longterm manufacturing partners, with a partnership spanning more than 20 years. Spectre has manufacturing in both Latvia and Vietnam and is a good example of how high environmental, social and ethical standards are held as high in Vietnam although it is considered a risk country. In addition to current standards, Spectre has ambitious environmental, social and ethical goals and full traceability. The company is B Corp certified and committed to Science Based Targets on climate action Spectre have decreased emissions from energy consumed in their own operations by 78% over the last year by switching to 100% renewable electricity in its Vietnam factories.Their CSR report includes accounts of how the company is performing. In 2022/2023 Spectre had a monthly instance of on average 0.8% of employees receiving below a living wage benchmark. This according to Living Wage Benchmark in Vietnam and Spectre's own calculator, based on SA8000 guidance for Latvia, calculated excluding any irregular bonuses and overtime pay. Most employees earn well above living wage without working overtime. Some exceptions to this occur, but Spectre aims for zero incidence. The factory management review cases handling incidents of employees receiving less than living wage, results in defining appropriate next steps to correct this. In 2022/2023 Spectre also reduced excess overtime cases with 85 %. (Spectre 2023)

This is the way Houdini works with monitoring and improving social sustainability and living wages with all of their manufacturers.

8.11.5 Code of Conduct

Houdini strive to establish and encourage long relationships with their suppliers where several areas of impact are equally important - social, environmental, and economic sustainability. Together with these manufacturers and suppliers Houdini work beyond the code of conduct to create responsible business and relationships. Consequently, the Houdini Code of Conduct only states the minimum requirements for working conditions and workplace rights in the value chain. It lists non-negotiable requirements that apply to the whole supply chain including garment manufacturers, suppliers, subcontractors and farms.

The CoC is based on and meet the standards of a whole range of international guidelines, organisations and declarations: UN Global Compact, International Labor Organization (ILO), OECD Guidelines, The UN Convention on the Right of the Child, The Universal declaration on Human Rights, Sustainable Development Goals (SDG), UN Guiding Principles on Business and Human rights, UN Convention against Corruption, Planetary Boundaries and Paris agreement.

CASE 7:

The Houdini Code of Conduct in a nutshell

FIRST OF ALL, suppliers are of course required to follow national law. Moreover, Houdini has a zero-tolerance to corruption and bribery. Employment with suppliers is freely chosen by the workers. There is no use of child labour. Workers are free to form and join associations and collective bargaining. No harassment and discrimination is allowed. Regular employment is provided. In addition, the following applies:

- Living wages are paid
- Overtime wages are paid
- Working hours may not exceeding legal limit and collective agreements
- Safe working conditions shall be provided
- A safe and healthy working environment
- Adequate education shall be provided and community building activities are encouraged
- Environmental policies shall be maintained, kept up to date, and complied with
- Partners must be willing and transparent in sharing information about working conditions and track data for a transparent supply chain
- Unapproved subcontracting is not permitted

9. Discussion

A LOT HAS HAPPENED SINCE the 2018 planetary boundaries assessment of Houdini sportswear, in science, in business in general, and at Houdini. The academic understanding of the planetary and social boundaries has improved, and important steps have definitely been made in the corporate world, but efforts are often piecemeal (Cornell and others, 2021). However, most companies still focus most of their efforts and reporting on climate, decent work and health, while many other planetary and social boundaries still remain underreported and unrecognised. Translating and applying the boundaries along increasingly complex and global value chains comes with a number of challenges (Cranston and Steffen, 2019) associated with more actors, greater geographical distances, multiple legal jurisdictions, and a myriad of other social, spiritual, and cultural values (Olsson and others, 2020). Even though Houdini have chosen to work with very few and advanced suppliers, it is difficult to access sufficient data to conduct a complete quantitative planetary and social boundaries assessments. Qualitative partnerships, work and assessments are therefor critical throughout the value chain and possible as long as the number of supplier partners is not too high.

Having said that, a number of studies have shown that sustainability efforts in the apparel industry cannot be confined to fibre choice or making individual products less destructive or regenerative. Promoting care, longer use and times worn before disposal has been shown to be the most important aspects (e.g. Roos and others, 2015; Dahlbo and others, 2017; Fletcher and Tham, 2019). That is, impact per kilo is not as important as impact per wear. As mentioned earlier, Sandin and others (2019) showed that the greenhouse gas emissions from a t-shirt can be cut in half if it is used twice as many times (see figure below, which also looks into the effects of using solar energy and walking instead of going by car to the store). Similar effects (≈ 50 % reduction of impact with twice as many wears) were shown also for energy use, toxicity, water depletion and land use.

From a planetary boundaries perspective, it is therefore promising that Houdini have continued to strive for timeless and durable designs, and for circular approaches like repair, rental and reuse, as these tend to have an overall positive effect, decreasing the company's impact on more or less all the planetary boundaries. The decision to broaden the perspective to also include efforts to promote and enable lifestyle changes among their customers and others is also encouraging.

Fig 20: Climate gains from combining interventions to reduce impact, based on Swedish clothing consumption. Doubling length of life for a garment reduces its carbon footprint by 49%. Source Sandin et al. 2019.

On a basic production level however, the choice of fibres, fabric and suppliers is still important from an environmental point of view. As is, sometimes even more so, the processes used to turn a fibre into fabric and fabric into garment. Scientific studies (e.g., Sandin and others, 2019b) have concluded for example that fineness of yarn and filaments as well as whether a fabric is knit or woven are two other aspects that affect impact greatly. The finer the fibre the more energy is required in production. However, fineness of yarn and filament is closely related to high functionality (light weight, comfort, quick dry etc) and reduced microfiber shedding, making it a balancing act in relation to Houdini's design principles. In producing materials the environmental cost of making a fabric as well as the gains of specific properties the fabric has and how this relates to its impact per wear needs to be considered.

Relatively few of Houdini's garments are made with woven fabric, primarily shell layers made to be water and wind resistant. A woven fabric has properties that are typically not found in a knit fabric - but pushing the developer and designing mindset: The prospect of a knit shell fabric could lower the impact of such garments significantly as weaving stands out with high scores for global warming, eutrophication and water scarcity (e.g., van der Velden, 2014, Higg MSI, 2022). Can it be done?

Hence, though the most significant factors are connected to longevity, versatility circularity Houdini should continue being careful when choosing both fibres, supplier and production methods.

9.1 Natural vs synthetic fibres

As seen in this report, Houdini has increased the share of natural fibres between 2015 and 2023. The question whether this has made Houdini more sustainable or not is not easy to answer. If natural fibres are not blended with synthetics, they are biodegradable which means that they don't contribute to plastic waste or microplastic pollution (the novel entities planetary boundary). But including the effects on other planetary and social boundaries like climate change, water use, novel entities, biodiversity, animal welfare and work environment, it all becomes much more complex to navigate even with the best intentions. There can also be big differences between different producers of the same raw materials.

Even if polyester is a fossil material, it comes with some benefits. Polyester fibres and fabrics, made right, are very durable, dry quickly and wick away moisture efficiently. Polyester fibres can also be recycled many times in a circular recycling system, almost without lowering the quality. Most of Houdini's polyester garments are made from recycled fibres, many are

recyclable and most are both. Moreover, production of polyester, especially recycled polyester, requires less water to produce than many other fibres. It is, however, important to remember that polyester, even when recycled, will ultimately be a pollutant. Whether we like it or not, and so far despite the best technological advancements, our human-made material loops always, inevitably, leak into the environment. This is one of the chief reasons we have a global microplastic problem, one important part of the reason researchers now conclude we are outside of the safe space for the novel entities boundary. All industrial resource loops exist inside biological ones, not side-by-side. The outermost loop is always the biosphere: air, water, and soil. As argued by the Biomimicry Institute (2020) it is time to recognize this and phase out synthetic fibres and design the majority of goods for ultimate biological degradation.

In this sense, natural fibres will be more sustainable than synthetic ones in the long run, but not if the natural fibres are produced in big monocultures and using excessive irrigation, chemical fertilisers and pesticides. Including raw materials, production, transportation, usage and disposal, all textile production has an environmental impact. That's why Houdini designs products to last as long as possible and that's the reason why the company offers clothing rentals, second hand sales and repair services.

Wool is one example that illustrates the complexities involved in analysing natural fibres' impact from a planetary boundaries perspective. Even though it is natural, in every stage of production, from breeding sheep to mothproofing garments, the wool industry can have a number of impacts on land, climate, air, and water. Most LCAs show that the CO2-equivalents released from wool production, mainly as methane produced from the sheep's digestive system, by far exceed the numbers for other fibres (e.g. Wiedemann and others, 2016). The release of methane from sheep is, however, not from a fossil source, it is biogenic and, if properly managed, an argument can be made that the many benefits of wool outweigh its climate impact. While grazing in very high stock numbers can cause vegetation change and soil erosion, regenerative management of wool production can contribute to keeping landscapes open and restore degraded grassland biodiversity, while improving soil health and increasing carbon sequestration. In this sense it is promising that Houdini are working together with their wool suppliers in Italy and New Zealand to further develop the ZQRX index for regenerative sheep farming.

Such regenerative approaches could also be beneficial from a socio-economic point of view, e.g. help keep sheep ranching alive as an important, but currently threatened, livelihood. So, it is crucial to make sure that the scale of the operations does not outgrow the ability of the land to sustain them. From a social (Doughnut) perspective it is also encouraging that the ZQRX index, and the regenerative approach in general, is also very committed to ethical production and animal welfare.

9.2 Using Life Cycle Assessments

Throughout this report we have analysed fibres with data from various LCAs and it is worth noting that the world of LCAs includes differences and disagreements on for example metrics and system boundaries, as well as challenges and limitations in assessing and comparing impact. LCAs are problematic to compare unless they were conducted using exactly the same methodology. Currently, no global generic LCA exists for the major fibres used in the textile and fashion industry.

Predominantly using cradle to gate rather than cradle to grave approaches means that use and disposal are seldom included in the LCA data. This omission means discounting a major part of the environmental impact. It also results in a partial view of the system, leaving out a segment, the consumers and their habits, that is crucial in a transition towards sustainability.

LCAs also focus on impacts per kilo, whereas impact per wear (how many times a garment is worn before disposed) has – as mentioned above – been concluded to be the most important aspect in a number of studies. Some fabrics are known to be worn many more times than others, and that should be included in sustainability calculations. Some fabrics are also lighter per surface area than others and can therefore produce more garments per kilo.

LCAs have also been reported to underestimate the overall benefits of some natural fibres, as some ecosystem services provided by their cultivation are difficult to quantify (see wool discussion above). Furthermore, since technology, environmental conditions, and locations of production change all the time, LCA data needs to be constantly updated to remain relevant. This is not currently the case.

9.3 Limitations of using databases with generic data

One LCA-based way of assessing the impact of fibres and fabrics is to use databases that collate (and normalise) LCA data. In this report we looked into the Higg MSI, which has increasingly been adopted in the apparel sector to signal or report sustainability efforts. The development of such tools to measure impact beyond climate and beyond fibre is an important and obviously challenging endeavour. Higg MSI scores are based on LCA data that has been vetted for comparability, which is in many ways a great strength of the Higg MSI. The Higg MSI is, however, not open source, so the calculations behind the scores are essentially hidden in a black box. Like many other LCA-based measures, databases such as the Higg MSI typically do not include the whole value chain. For example, there is no information about whether a garment will release microplastics or if it is biodegradable or recyclable. This limitation has been compared to a clock face, where the data presented only looks at midday to 3pm – a very selective part of the total impact (The Guardian, 2022). Any effort seeking to assess the sustainability of a product needs to look from cradle to grave (or recycling), not just from cradle to shop.

In conclusion, our investigation found that – so far – existing assessment platforms, including Higg MSI, are insufficient for assessing impacts on the planetary boundaries. However, many of the challenges in in-

cluding all nine planetary boundaries in such databases are the same as for accurately representing them in LCA studies.

9.4 The need for a holistic approach

The apparel industry urgently needs to take a holistic planetary perspective. As mentioned earlier, the industry is so large that it is becoming an important factor shaping the state of the whole planet while contributing to unwanted serious negative social harms (Cornell and others, 2021). It is not enough to only concentrate on parts of the value chain and a few of the boundaries like climate, water and novel entities. The holistic approach needed has to address all parts of the value chain and take the interactions between planetary boundaries into account, and include social aspects of course.

A narrow focus on climate, like fervently focusing on minimising the carbon footprint of a garment, might lead to increased water use or negative effects on biological diversity and working conditions. Similarly, a garment like Houdini's Mono Air, made by a new material focused on minimising microplastic pollution from washing (the user phase), might require a more complicated production process resulting in higher climate impact per kilo product (but not necessarily per wear). These kinds of trade-offs between impacts on different planetary boundaries in the various parts of the value chain must always be analysed when developing new materials. As argued by Palm and others (2021) reducing planetary pressures from the apparel industry also requires greater recognition of other aspects than the material flows, that is, to put more emphasis on the global fashion system's social drivers, such as cultural values and social norms.

Tackling these challenges means embarking on an industry-wide transformation so profound that it reshapes the entire business ecosystem. A combination of circular approaches (where long-lasting products are used, repaired and reused and then finally recycled) and clear science-based priorities derived from the planetary and social boundaries frameworks, is a good foundation for such a sustainable transformation. To profoundly rethink the apparel industry in this way means putting the health and survival of our planet before short-term business interests and economic growth.

For a relatively small outdoor company like Houdini this is not only about contributing to the transformation by doing their share and tracking the environmental savings of changes in the production of their own products. It is also about being a role model and challenging business-as-usual while exploring what they as a brand can do to impact their customers' lifestyle (from outdoor experiences, via mobility and nutrition to activism) and how that influences the overall environmental impact.

10. Conclusion

- A lot has happened since the 2018 planetary boundaries assessment of Houdini sportswear, in science, in business and at Houdini.
- It is not enough to analyse the production of individual products to manage the effect on planetary and social boundaries. Therefore, Houdini has decided to broaden the perspective to also include how to encourage longer use of their products, as well as the values and lifestyles that they can enable and promote.
- The cases and sustainability initiatives reported in this study show that Houdini are working hard to further improve and to minimise their impacts on planetary boundaries – they even strive to have a long-term positive influence.
- Developing the circular business model, including designing for long use, is key from a planetary boundaries perspective as it reduces the need for using virgin raw materials and producing new garments. Hence, the circular model (rent, repair, reuse, recycle) is the most effective way to reduce the overall impact on all planetary boundaries.
- Several of the goals of the ambitious Houdini trailmap have already been reached, and the remaining 2030 goals are promising if the company can continue improving and create a truly circular system, where long-lasting products can be used, repaired and reused and then finally become new resources again.
- From 2021 all the fabrics used by Houdini are recycled, recyclable, renewable, biodegradable or Bluesign certified.
- Houdini has since 2018 become completely fluorocarbon-free, only producing shell layers that are weatherproofed through a combination of biodegradable components and nature-inspired materials.
- Houdini has increased the share of natural renewable fibres like wool and tencel from 6 % to 11 % since 2014/15. Increasing the share of natural fibres is a good step in the long run, but also these natural fibres can have large effects on some planetary boundaries if not managed and monitored properly.
- Alongside increasing the share of natural fibres Houdini has for example deepened its collaboration with the suppliers of renewable wool fibres to develop a regenerative production and assess it with a new index (RX) that evaluates regenerativity based on 15 KPIs across three areas: people, planet and animal welfare (hence taking both planetary and social boundaries processes into account).
- Still, 47 % of the fibres used are virgin synthetic ones, implying room for improvement. There is still work to be done replacing virgin synthetic fibres with recycled or natural ones and Houdini's 2030-goals provide a clear trailmap and deadline for when to achieve a complete phase-out.

- One of the most difficult cases when it comes to circularity is Houdini's iconic Power Houdi, since it is made of three different synthetic materials that can not yet be separated to be recycled. The Power Houdi is, however, on average used 1287 times for over 10 years, and is therefore an illustrative example of how maintenance, use and care of existing garments can decrease the overall impact on planetary boundaries.

- It is important to address all parts of the value chain in order to improve future company performance from a planetary and social boundaries' perspective. Consequently, whereas the 2018 pilot study focused on fibre production, this study increased the scope to also look at Houdini's work with scope X and consumer use.

- Looking at Houdini's suppliers from a social perspective, only 10 % of garments and 7 % of fabrics currently come from risk countries (China and Vietnam), according to the Amfori BSCI (Business Social Compliance Initiative) Country Risk Classification. Houdini's selective choice of suppliers, extensive code of conduct and qualitative work is critical to safeguard planetary and social boundaries.

- When it comes to social boundaries, Houdini updated their code of conduct in 2021 referring to international standards to add clarity and validity to minimum requirements, but also going beyond them when necessary.

11. Recommendations

- Houdini should continue to develop the circular business model according to their 2030 trailmap – designing for long use and increasing rentals, repair, reuse and recycling – this is the most effective way to reduce the impact on planetary boundaries.

- As a part of Houdini's collection is still made of mixed synthetic materials, they should continue their work on developing renewable materials like wool and Tencel, and make sure these can be produced regeneratively and last long enough to compare with synthetic materials (e.g. providing regenerative and wool-based alternatives to the Power Houdi).

- Houdini should continue their efforts in looking into planetary boundaries rarely covered by the clothing sector, like biodiversity and nutrient pollution, it is more important than ever and could give them a competitive advantage

- As a natural next step in the strive to work closely aligned with science, Houdini should explore the possibility to set science-based targets for both climate and nature in collaboration with the Science-Based Targets Network.

- Houdini should continue developing their collaboration with suppliers on how fabrics and garments are manufactured, e.g. how fabrics are dyed, what coarseness of fibres are used and how the garments are sewn together, including whether a material is knitted or woven. To develop materials that have the least possible environmental impact while maintaining top functionality according to Houdini's ambitious design principles.

- An expanded collaboration with suppliers could also be an important step toward being able to gather enough reliable data to measure the actual impact on social and planetary boundaries from Houdini's own products over their entire life-cycles.

- Houdini should continue their exploration of the field of biomimicry (innovations inspired by nature), looking into how the company itself and its value chain could function more as an ecosystem and reconnect further to the biosphere. It could help answer questions like: How do we design for decomposition? How do we promote regenerative agriculture and nature-inspired technologies?

- Future strategies to improve company performance from a planetary boundaries perspective should continue being combined with an analysis for how these strategies would contribute to, or hinder reaching the social boundaries of the Doughnut model.

- Houdini should continue to expand their work within the sustainable lifestyle initiative to promote increased awareness and behaviours among customers and others to shift towards less impactful and regenerative lifestyles. As part of this they should also assess how the initiative does contribute to more encounters with nature and raises awareness of the need to set aside more of the planet to safeguard biodiversity.

12. References

Amfori BSCI, 2021. Country Risk Classification 2020. Downloaded 2024.01.19 from https://www.amfori.org/sites/default/files/amfori-2020-11-12-Country-Risk-Classification-2021_0.pdf

The Biomimicry Institute. 2020. Nature of Fashion: Moving towards a regenerative system.

Böcklin, D., G. Goffetti, H. Baumann, A-M. Tillman, T. Zobel. 2020. Environmental assessment of two business models - a life cycle comparison between a sales and a rental business model in the apparel sector in Sweden. Report no. 2020:02 Department of Technology Management and Economics. Division of Environmental Systems Analysis. Chalmers University of Technology. Gothenburg, Sweden

Chaudhary, A., T. M. Brooks. 2018. Land Use Intensity-Specific Global Characterization Factors to Assess Product Biodiversity Footprints. Environmental Science & Technology. 52 (9), 5094-5104. DOI: 10.1021/acs.est.7b05570

Church R, Walsh M, Engel K and Vaupel M. 2022. A Biodiversity Guide for Business. Berlin, Germany: WWF.

CLImB, 2023. Information retrieved from https://climb.ecogain.se/ in February, 2023.

Cranston, G. and Steffen, W. 2019. Linking planetary boundaries to business: The first White Paper in Kering's series on Planetary Boundaries for Business. Cambridge Institute for Sustainability Leadership (CISL).

Cornell, Häyhä and Palm. 2021. A sustainable and resilient circular textiles and fashion industry: towards a circular economy that respects and responds to planetary priorities. A Research Report by Stockholm University's Stockholm Resilience Centre for the Ellen MacArthur Foundation and H&M Group. https://www.stockholmresilience.org/download/18.66e0efc517643c2b8103605/1617805679501/Sustainable%20Textiles%20Synthesis%20Report.pdf

Ian T. Cousins, Jana H. Johansson, Matthew E. Salter, Bo Sha, Martin Scheringer. 2022. Outside the Safe Operating Space of a New Planetary Boundary for Per- and Polyfluoroalkyl Substances (PFAS). Environmental Science & Technology 56 (16): 11172-11179. https://doi.org/10.1021/acs.est.2c02765

Downing, A., Bhowmik, A., Collste, D. Cornell, S.E., Donges, J., et.al. 2019. Matching scope, purpose and uses of planetary boundaries science. Environ. Res. Lett. 14 073005. DOI: 10.1088/1748-9326/ab22c9

Elhacham E, Ben-Uri L, Grozovski J, Bar-On YM, Milo R. Global human-made mass exceeds all living biomass. Nature. 2020 Dec;588(7838):442-444. DOI: 10.1038/s41586-020-3010-5. PMID: 33299177.

Ellen MacArthur Foundation. 2017. A new textiles economy: Redesigning fashion's future. https://ellenmacarthurfoundation.org/a-new-textiles-economy

Ellen MacArthur Foundation. 2019. The butterfly diagram: visualising the circular economy. https://ellenmacarthurfoundation.org/circular-economy-diagram. Retrieved November 2, 2022.

European parliament, 2017. https://www.europarl.europa.eu/news/en/headlines/society/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographic)

Fletcher, K. and Tham, M. 2019. Earth Logic: Fashion Action Research Plan. London: The J J Charitable Trust. https://earthlogic.info/

Folke, C., Å. Jansson, Rockström, J., P. Olsson, S.R. Carpenter, F.S Chapin, A-S. Crepin, Daily, G., K. Danell, J. Ebbesson, T. Elmqvist, V. Galaz, F. Moberg, M. Nilsson, H. Österblom, E. Ostrom, Å. Persson, G. Peterson, S. Polasky, W. Steffen, B. Walker and F. Westley. 2011. Reconnecting to the biosphere. Ambio 40: 719–738

Folke, C., Polasky, S., Rockström, J. and others. 2021. Our future in the Anthropocene biosphere. Ambio 50:834–869.

Geyer, R.; Jambeck, J. R.; Law, K. L. Production, Use, and Fate of All Plastics Ever Made. Sci. Adv. 2017, 3 (7), e1700782.

Giusti, M., S. Barthel, L. Marcus. 2014. Nature Routines and Affinity with the Biosphere: A Casestudy of Preschool Children in Stockholm. Children, Youth and Environments 24(3): 16-42

Hamilton, H.A., Ivanova, D., Stadler, K. and others. Trade and the role of non-food commodities for global eutrophication. Nat Sustain 1, 314–321 (2018). https://doi.org/10.1038/s41893-018-0079-z

IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.

IPCC, 2018. Special Report: Global Warming of 1.5 ºC. https://www.ipcc.ch/sr15/

IPCC, 2019. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Available at: https://www.ipcc.ch/srocc/

IPCC, 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1/

IPCC, 2022. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg2/

Wang-Erlandsson, L., Tobian, A., van der Ent, R. J., Fetzer, I., te Wierik, S., Porkka, M., Staal, A., Jaramillo, F., Dahlmann, H., Singh, C., Greve, P., Gerten, D., Keys, P.W., Gleeson, T, Cornell, S. E., Steffen, W., Bai, X., Rockström, J. 2022. A planetary boundary for green water. Nature Reviews Earth & Environment. https://doi.org/10.1038/s43017-022-00287-8. Free full text version available at: https://rdcu.be/cL78K

Karlberg, Å., T. Hägglund, A. Enetjärn, L. Rydin, J. Axelsson. 2022. Ecogain Biodiversity Index 2022 - Ranking biodiversity in business. Ecogain. Sweden.

KPMG, 2018. How to report on the SDGs: What good looks like and why it matters. Report, KPMG.

McKinsey. 2019. The state of fashion. Report by McKinsey & Co.
https://www.mckinsey.com/~/media/mckinsey/industries/retail/our%20insights/the%20state%20of%20fashion%202019%20a%20year%20of%20awakening/the-state-of-fashion-2019-final.ashx

Metabolic. 2017. One planet approaches: methodology mapping and pathways forward. WWF & IUCN. Available from: https://www.metabolic.nl/publications/one-planet-approaches-methodology-mapping-and-pathways-forward/

Moore, M. L., Riddell, D. and Vocisano, D. 2015. Scaling Out, Scaling Up, Scaling Deep: Strategies of Non-profits in Advancing Systemic Social Innovation. Journal of Corporate Citizenship 58:67-84

Morgan, L.R. and Birtwistle, G. 2009. An investigation of young fashion consumers' disposal habits. International Journal of Consumer Studies 33(2): 190-198.

D. W. O'Neill, A. L. Fanning, W. F. Lamb, and J. K. Steinberger. 2018. A good life for all within planetary boundaries. Nature Sustainability, vol. 1, no. 2, pp. 88–95, doi: 10.1038/s41893-018-0021-4.

Niinimäki, K. Peters, G., Dahlbo, H., Perry, P., Rissanen, T. and Gwilt, A. 2020. The environmental price of fast fashion. Nature Reviews; Earth and Environment.

OECD. 2022. Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options, OECD Publishing, Paris, https://doi.org/10.1787/de747aef-en.

Olsson, P., Bohlin, M., Moberg, F. 2020. Effects of transformations to climate-neutral societies on low- and middle-income countries. Brief for Swedish Leadership for Sustainable Development (SLSD) by Stockholm Resilience Centre, Stockholm University.

Palm, C., Cornell, S., and Häyhä, T. 2021. Making Resilient Decisions for Sustainable Circularity of Fashion. Circular Economy and Sustainability 1: 651–670. https://doi.org/10.1007/s43615-021-00040-1

Perrigo, A., Vrasdonk, E., Durkin, L., & Antonelli, A. 2020. The full impact of supermarket products. Springer Nature Sustainability Community. https://sustainabilitycommunity.springernature.com/posts/the-full-impact-of-supermarket-products#contributors

Persson, L., Carney Almroth, Collins, C.D., Cornell, S., de Wit, C. et.al. 2022. Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. Environ. Sci. Technol., https://doi.org/10.1021/acs.est.1c04158

Remme, R. P., H. Frumkin, A. D. Guerry, A. C. King, L. Mandle, C. Sarabu, G. N. Bratman, B. Giles-Corti, P. Hamel, B. Han, J. L. Hicks, P. James, J. J. Lawler, T. Lindahl, H. Liu, Y. Lu, B. Oosterbroek, B. Paudel, J. F. Sallis, J. Schipperijn, R. Sosič, S. de Vries, B. W. Wheeler, S. A. Wood, T. Wu, and G. C. Daily. 2021. An ecosystem service perspective on urban nature, physical activity, and health. Proceedings of the National Academy of Sciences 118 (22) e2018472118.

RISE. 2022. PFAS substitution guide for textile supply chains. RISE rapport 2022:98. https://www.ri.se/sites/default/files/2022-10/PFAS_Substitution_Guide_for_Textile_Supply_Chains.pdf

Sandin, G. and Peters, G.M. 2018. Environmental Impact of Textile Reuse and Recycling—A Review. Journal of Cleaner Production, 184, 353-365.

Sandin, G., Roos, S., Spak, B., Zamani, B. and Peters, G. 2019a. Environmental assessment of Swedish clothing consumption
Mistra Future Fashion report 2019:05. http://mistrafuturefashion.com/wp-content/uploads/2019/08/G.Sandin-Environmental-assessment-of-Swedish-clothing-consumption.MistraFutureFashionReport-2019.05.pdf

Sandin, G., Roos, S., and Johansson, M. 2019b. Environmental impact of textile fibers – what we know and what we don't know. "The fiber bible", part 2. Mistra Future Fashion report number: 2019:03. http://mistrafuturefashion.com/wp-content/uploads/2019/03/Sandin-D2.12.1-Fiber-Bibel-Part-2_Mistra-Future-Fashion-Report-2019.03.pdf

Science Based Targets Network. 2020. Science-Based Targets for Nature: Initial Guidance for Business.

Solomon, S., Alcamo, J. & Ravishankara, A.R. Unfinished business after five decades of ozone-layer science and policy. Nat Commun 11, 4272 (2020). https://doi.org/10.1038/s41467-020-18052-0

Spectre, 2023, CSR Report 2022/2023 - Issuu. https://issuu.com/spectre.dk/docs/22-23-csr-report?fr=sNGExOTUxNzgyMTk

Steffen, W., Å. Persson, L. Deutsch, J. Zalasiewicz, M.Williams, K. Richardson, C. Crumley, P. Crutzen, C. Folke, L. Gordon, M. Molina, V.Ramanathan, J. Rockström, M. Scheffer, H.J. Schellnhuber, and U. Svedin. 2011. The Anthropocene: from global change to planetary stewardship. Ambio 40:739–761

Steffen, W and Morgan, J. 2021. From the Paris Agreement to the Anthropocene and Planetary Boundaries Framework: an interview with Will Steffen. Globalizations 18 (7): 1298-1310. DOI: https://doi.org/10.1080/14747731.2021.1940070

Textile Exchange, 2021. Biodiversity Insights Report: First global baseline of the apparel and textile industry. https://mci.textileexchange.org/biodiversity/insights/

Textile Exchange, 2021. Preferred Fiber & Materials Market Report 2021. https://textileexchange.org/wp-content/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf

The Guardian, 2022. "Fashion brands pause use of sustainability index tool over greenwashing claims". Fleur Britten, 28 Jun 2022. https://amp-theguardian-com.cdn.ampproject.org/c/s/amp.theguardian.com/fashion/2022/jun/28/fashion-brands-pause-use-of-sustainability-index-tool-over-greenwashing-claims

TNFD, 2022. The TNFD Nature-Related Risk and Opportunity Management and Disclosure Framework. Beta v0.2, June 2022. https://framework.tnfd.global/wp-content/uploads/2022/06/TNFD-Framework-Document-Beta-v0-2.pdf

Townsend, S. 2020. We Urgently Need 'Scope X' Business Leadership For Climate. The Forbes. Jun 29, 2020. https://www.forbes.com/sites/solitairetownsend/2020/06/29/we-urgently-need-scope-x-business-leadership-for-climate/?sh=6929b4c84dd3

Tradera. 2022. Top 20 clothing brands. https://www.tradera.com/info/tradera-circular-brands-top-20-clothing-brands/

World Economic Forum. 2021. Net-Zero Challenge: The supply chain opportunity INSIGHT REPORT. https://www3.weforum.org/docs/WEF_Net_Zero_Challenge_The_Supply_Chain_Opportunity_2021.pdf

Zalasiewicz, J., Waters, C.N., Ellis, E.C., Head, M.J., Vidas, D., Steffen, W., Thomas, J.A., Horn, E., Summerhayes, C.P., Leinfelder, R., McNeill, J.R., Gałuszka, A., Williams, M., Barnosky, A.D., Richter, D., Gibbard, P.L., Syvitski, J., Jeandel, C., Cearreta, A., Cundy, A.B., Fairchild, I.J., Rose, N.L., Sul, J.A.I, Shotyk, W., Turner, S., Wagreich, M., and Zinke, J. 2021. The Anthropocene: Comparing its meaning in geology (chronostratigraphy) with conceptual approaches arising in other disciplines. Earth's Future 9(3): https://doi.org/10.1029/2020EF001896

WHO. 2022. Ambient air pollution. https://www.who.int/teams/environment-climate-change-and-health/air-quality-and-health/ambient-air-pollution (accessed 3 March 2022).

WMO. 2021. State of Climate Services: Water. A report by World Meteorological Organization (WMO-No. 1278).

World Economic Forum. 2021. World Economic Forum (WEF, 2021). Net-Zero Challenge: The supply chain opportunity. Insight Report.https://www3.weforum.org/docs/WEF_Net_Zero_Challenge_The_Supply_Chain_Opportunity_2021.pdf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